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Superfund Record of Decision (EPA Region 2): Upjohn Manufacturing Company, Barceloneta, Puerto Rico (First Remedial Action) September 1988

(U.S.) Environmental Protection Agency, Washington, DC

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16. Abstract (Limit: 200 words)

The Upjohn Manufacturing Company (UMC) site is located in the Barceloneta industrial park on the north coast of Puerto Rico. Land use in the surrounding area is industrial, agricultural, and rural residential. The site is in a sparsely populated rural region and lies above the island's largest aquifer, which serves as a source of drinking water for over 12,000 area residents. In addition, the aquifer discharges to a wetland area to the north, which supports a large aquatic and bird population. The site lies in a limestone region characterized by karst terrain developed by dissolution of the existing limestone formations, and typified by closed depressions, sinkholes, and subsurface conduits. Between August and September 1982, UMC dispatched approximately 15,300 gallons of a manufacturing by-product waste mixture estimated to be comprised of 65 percent carbon tetrachloride and 35 percent acetonitrile to a leaking underground storage tank (UST), resulting in the release of all of the waste into the ground. Investigation by UMC determined that carbon tetrachloride contamination had migrated offsite approximately 2 miles to the north and occupied an area of about 2.1 mi^2. → sq. miles Consequently, five local water supply wells were closed in 1982 due to the potential for carbon tetrachloride contamination, and UMC provided a permanent alternate water supply to users. In 1983, UMC began implementing remedial actions to remove carbon
(See Attached Sheet)

17. Document Analysis a. Descriptors

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First Remedial Action - Final
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EPA

Superfund Record of Decision:

Upjohn Manufacturing Company, PR

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16. ABSTRACT (continued)

tetrachloride from the soil and ground water: this included the installation and operation of a vacuum extraction system until March 1988; ground water pumpage from the AH Robins well adjacent to and north of the site until 1985; installation and operation of a second ground water contaminant recovery extraction well, UE-1, on the UMC facility in 1984, with air stripping and residual discharge to a sinkhole; and placement of a concrete cap over the tank farm. In 1987, because of residual ground water contamination that has remained both on and offsite, EPA ordered UMC to continue its remedial activities including resuming operation of the vacuum extraction system, pumping extraction well UE-1, and ground water monitoring, as well as determining the feasibility of restoring all or portions of the aquifer to health-based levels. This ROD addresses the residual ground water contamination resulting from the 1982 UST leak at the UMC facility. The possibility of residual contamination in the soil as a continuing source of carbon tetrachloride contamination in the ground water will be addressed by the EPA RCRA program and will not be a part of this remedial action. The primary contaminant of concern affecting the ground water is carbon tetrachloride.

→ is given. ← end

The selected remedial action for this site includes: ground water pump and treatment from the UE-1 and AH Robins wells using air-stripping, followed by discharge of the treated water to an existing sinkhole; ground water pump and treatment using air tripping from the public supply well followed by distribution to the public water upply system; installation and operation of two to four additional offsite extraction wells with air stripping and recharge to the ground water; installation of chloride monitoring wells near the coastline to monitor potential salt-water encroachment; and long-term ground water monitoring. Because it is not known whether contaminant levels in the aquifer can be reduced to the MCL, EPA will re-evaluate this remedy within five years of operation to determine the allowable contaminant levels that must be met before the extraction wells are shut down. If a decision is made that any portion of the aquifer will not be restored, a waiver from the MCL for reasons of technical impracticability will be evaluated at that time. The estimated capital cost for this interim remedial action is $2,200,000-$6,200,000 with annual O&M of $400,000-$700,000.

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DECLARATION STATEMENT

RECORD OF DECISION

SITE NAME AND LOCATION

Upjohn Manufacturing Company
Barceloneta, Puerto Rico

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedial action for the Upjohn Manufacturing Company (UMC) Site, in Barceloneta, Puerto Rico, developed in accordance with CERCLA, as amended by SARA, and to the extent practicable, the National Contingency Plan. This decision is based on the administrative record for this site.

The Commonwealth of Puerto Rico has concurred on the selected remedy.

DESCRIPTION OF THE SELECTED REMEDY

This ROD addresses the residual carbon tetrachloride (CCl_4) groundwater contamination resulting from the 1982 underground tank leak at the UMC facility. The response action will address the principal threat posed by the groundwater contamination at the site.

The major components of the selected interim remedy include:

- Continued pumpage of ground water extraction well UE-1 at 840 gpm with treatment by an upgraded air-stripping system and discharge to an existing sinkhole located northwest of the UMC facility.
- Pumpage of the AH Robins well at 450 gpm plus the installation and pumpage of two new extraction wells each at 800 gpm, with treatment by the UE-1 air-stripping system and discharge to the existing sinkhole.
- Continued pumpage of the Garrochales #3 public supply well (not currently treated) at 2000 gpm with treatment by air stripping and subsequent distribution to the public water supply system. An evaluation of replacing this well with an artesian well will be conducted during design. Because this well is not an integral part of the remediation scheme, it may be taken out of service if it is replaced.
- If the two new extraction wells prove to be effective at removing contaminants from the aquifer, additional extraction wells will be added, in a phased approach,

with treatment by air stripping and recharge to the groundwater. It is estimated that two to four additional wells will be installed and pumped at approximately 800 gpm each.

- Installation of chloride monitoring wells near the coastline to monitor potential salt water movement.

- Long-term monitoring of groundwater to track contaminant movement and assess performance of the groundwater extraction wells.

- A reevaluation of the interim remedy within five years of operation to determine whether it should be continued or modified.

DECLARATION

Consistent with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as amended by the Superfund Amendments and Reauthorization Act of 1986, and the National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR Part 300, I have determined that the selected interim remedy is protective of human health and the environment consistent with the purpose of this remedial action. For groundwater extracted and treated, the remedy attains federal and state requirements that are applicable or relevant and appropriate. Consistent with the scope and purpose of this interim remedy, this action is cost effective and utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable. This action satisfies the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element.

Because this remedy will result in hazardous substances remaining on-site above health-based levels, a review will be conducted within five years after commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

9-30-88
Date

William J. Muszynski, P.E.
Acting Regional Administrator

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ROD DECISION SUMMARY

SITE NAME, LOCATION, AND DESCRIPTION

The Upjohn Manufacturing Company (UMC) site is located on the north coast of the island of Puerto Rico in the Barceloneta industrial park, a rural region approximately 1.6 miles west of "Cruce-Davila," which is the local name for the intersection of State Roads 2 and 140 (see Figure 1). This area lies on a five-mile wide coastal plain with regional topography sloping gradually down to the north and to the Atlantic Ocean which lies about 3.7 miles to the north. Small hills known as mogotes surround the facility. Across the road from the UMC property is the AH Robins Company and the Tiburones community. Nearby to the north is the Cambalache State Forest (see Figure 2).

The site is located in the north coast limestone region of Puerto Rico. This sparsely populated area lies above the island's largest aquifer, which serves as a source of drinking water to over 12,000 area residents who rely on public and private wells. The region is traversed by six rivers whose headwaters are found in the volcanic terrain to the south, and which flow northerly to the Atlantic Ocean. The UMC site lies in the drainage area bounded to the west by Rio Grande de Arecibo and to the east by Rio Grande de Manati. The Cano Tiburones forms the northern boundary.

The region is characterized by a tropical, mature karst terrain which includes closed depressions, sinkholes (dolines), subsurface conduits and an absence of surface water bodies. The karst developed by dissolution of the existing limestone formations. Blanket sands fill the depressions or valleys between the mogotes, at depths ranging from approximately 3 feet to greater than 100 feet.

The Aymamon and Aguada formations comprise the unconfined water table aquifer which has high values of permeability. The total thickness of these formations is approximately 709 feet and 1086 feet, respectively. The water table can be found approximately 300 feet below the spill site at UMC within the Aymamon Formation (see Figure 3). Below the Aguada Formation lie the Cibao and Lares formations which comprise the confined artesian aquifer. The total thickness of each of these formations is approximately 1004 feet and 1017 feet to 1657 feet, respectively (see Figure 4).

The Aymamon limestone is subject to high degrees of weathering and dissolution into underground cavities, usually following vertical regional faults. Two sets of vertical faults intersect in this region at right angles, leaving residual hills and sinkholes. Due to the cavernous nature of the formation, the transmissivity and productivity of the Aymamon limestone is high. Although vertical transmissivity is reduced by the inter-bedded clay layers, it is locally facilitated by sinkholes.

The Aguada formation is a more massive, less cavernous, and more resistant limestone with a lower lateral and vertical transmissivity than the Aymamon.

In the vicinity of UMC, groundwater within the water table aquifer generally flows to the north or slightly northeast, towards its discharge point into the Cano Tiburones, and ultimately the Atlantic Ocean. However, with flooding conditions, the general groundwater flow has been observed to be toward the northwest.

SITE HISTORY AND ENFORCEMENT ACTIVITIES

In mid August 1982, UMC resumed, after one year, a batch production process for the manufacture of the antibiotic Clindamycin, at their Barceloneta facility in Puerto Rico. This process generates a waste mixture of carbon tetrachloride (CCl_4) and acetonitrile. Between August 16, 1982 and September 3, 1982, nine batch processes were run. Approximately 15,300 gallons of this mixture were dispatched to an underground tank (identified as FA-129) (see Figure 5) before it was realized in mid September 1982 that the waste tank was empty and that the waste product had been released into the ground. The chemical components of the waste stream that entered the leaking underground tank were never carefully quantified. However, it is believed that the composition of material in the tank was 65% CCl_4 and 35% acetonitrile. Inspection of the failed tank revealed that it had ruptured in at least three locations. Inspections of most of the remaining tanks in the tank farm indicate the possible leakage from these tanks prior to the loss of waste stream in 1982. Possible spills from loading and unloading stations near the tank farm as well as from maintenance work on pipe and tank fixtures may have contributed to the contamination at the site, which may have been occuring before August 1982.

Five local water supply wells (Garrochales #1 and #2, Tiburones, AH Robins, and Hillside Motel) were shut down due to CCl_4 contamination or the threat of contamination resulting from the spill. Acetonitrile was not detected in any well. UMC, along with several local industries, provided a temporary alternate water supply to the users of those water supply wells until a permanent alternate water supply was provided for by UMC. UMC replaced the Puerto Rico Aqueduct and Sewerage Authority (PRASA) public supply wells, Garrochales #1 and #2, with a new water supply well, the Garrochales #3 well. To date, water from this well has not been provided with any type of treatment before being distributed through the PRASA water supply system.

Results of soil and groundwater investigations conducted by UMC following the spill indicated the presence of CCl_4 contamination in the soil and groundwater. Soil investigations delineated the zones of highest contamination within the unsaturated zone in and around the tank farm. Investigations revealed that most of the CCl_4 remained within the upper blanket sand deposits 25 to 100 feet below the ground surface in the unsaturated zone. Exceptions were noted, however, where elevated levels of CCl_4 were found in very deep deposits of the blanket sands at depths ranging from 100 to 210 feet below the ground surface.

Considering the impracticality of excavating soil to such depths, a vacuum extraction system was installed by UMC at the site in 1983, which removed CCl_4 vapors from the soil. Each vacuum extraction well in the system was in operation until nondetectable levels of CCl_4 vapors were observed over a period of time. The system was shut down in its entirety in March 1988.

Groundwater investigations conducted by UMC included the installation of 22 groundwater monitoring wells (MW-1 through MW-23, excluding MW-2), from November 1982 through December 1983, in the vicinity of UMC (see Fig. 6). Samples from these wells were used to determine groundwater quality, flow direction and rate of movement. Based on data collected from the monitoring wells, it was determined that the CCl_4 contamination in the groundwater had migrated off site approximately 2 miles to the north. Acetonitrile was not detected in the water table aquifer nor in the underlying artesian aquifer. Trace amounts of CCl_4 were occasionally detected in the underlying artesian aquifer, but the mean concentration was less than 0.5 parts per billion (ppb).

In 1983, UMC, with the support and oversight of the major regulatory agencies on the island, began implementation of remedial actions in attempts to remove the CCl_4 from the soil and groundwater. These actions included: the pumpage of the AH Robins well, the first well outside of the UMC facility at which CCl_4 associated with the UMC spill was detected, as a means of recovering the contaminated groundwater; the installation and operation of a vacuum extraction system, an innovative technology, within the UMC tank farm soils to remove CCl_4 vapors from the unsaturated zone; the installation and operation of a second groundwater contaminant recovery extraction well, UE-1, located on the UMC facility; and placement of a concrete cap over the tank farm to eliminate precipitation infiltration and reduce the migration of CCl_4 from the soil into the groundwater.

The UMC site was placed on the National Priorities List (NPL) in September 1983. In May 1984, UMC drafted a Remedial Investigation/ Feasibility Study (RI/FS) Report which documented the soil and groundwater investigations as well as the remedial actions taken by UMC to remove CCl_4 from the soil and groundwater and to provide alternate water supplies. EPA did not accept the 1984 draft RI/FS Report prepared by UMC because the extent of groundwater contamination had not been fully defined and the FS was not performed in accordance with the National Hazardous Substances Pollution Contingency Plan (NCP).

The use of the AH Robins well as a groundwater contaminant recovery well was discontinued in 1985 because of the greater effectiveness of well UE-1, which became operational in 1984.

UMC has continued to operate well UE-1 as a groundwater extraction well, discharging treated water from an air-stripping unit to an existing sinkhole, and has continued to sample selected groundwater monitoring wells and threatened water supply wells on a monthly basis.

Both soil and groundwater treatment systems were effective in removing contaminants from the environment. However, residual CCl_4 contamination has remained in the groundwater on site and has migrated off site as well. It is possible that residual CCl_4 may also exist in the unstaturated zone on site.

On June 26, 1987, EPA issued an Administrative Order on Consent to UMC which required UMC to perform additional remedial investigative studies as well as prepare a feasibility study with respect to the site in order to, among other things, gather further information about the groundwater contamination at the site and address alternatives for its remediation. The order also required UMC to continue to pump its groundwater extraction well (UE-1) and its vacuum extraction wells, conduct groundwater monitoring, and perform certain other actions. One of the primary objectives of this order was to ensure that the feasibility study to be prepared, would conform to the requirements of the Comprehensive Response Compensation and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 (CERCLA), and the NCP.

Pursuant to the June 26, 1987 Administrative Order, UMC submitted an RI Report, a draft FS Report and, after receiving comments from EPA, an amended FS Report. However, EPA found these reports to be deficient. EPA thus tasked its contractor, Camp Dresser & McKee Federal Programs Corporation (CDM-FPC), to perform additional groundwater sampling to define further the extent of CCl_4 contamination and to verify existing data from UMC, and to prepare a FS Report to address the residual groundwater contamination. The CDM-FPC FS Report was completed and accepted by EPA in June 1988.

COMMUNITY RELATIONS

The 1988 Draft FS Report, prepared by CDM-FPC, was released for public comment along with the Proposed Remedial Action Plan (PRAP) on July 12, 1988. The 30-day comment period concluded on August 10, 1988. A public meeting was held on July 21, 1988 at the Barceloneta Mayor's Office to discuss the FS and PRAP, answer questions, and solicit citizens' comments. A response to each significant comment received during the public comment period is included in the attached Responsiveness Summary.

SCOPE and ROLE of RESPONSE ACTION

This ROD addresses the residual CCl_4 groundwater contamination resulting from the 1982 underground tank leak at the UMC facility. The response action will address the principal threat posed by the contaminated groundwater at the site.

It is possible that residual CCl_4 contamination may exist in the unsaturated zone which may represent a continuing source of CCl_4 contamination to the groundwater. This possible source will be addressed separately by the EPA RCRA program and will not be part of this ROD.

SITE CHARACTERISTICS

Extent of Contamination

The chemical components of the waste stream that entered the leaking underground tank were never carefully quantified. UMC reported the composition of material in the tank to be 65 percent CCl_4 and 35 percent acetonitrile. Chloroform and methylene chloride are decomposition products of CCl_4; therefore, it is likely these compounds were also present in the spill and/or in the soil and/or groundwater soon after the spill.

Qualitative analyses by UMC of the vented fumes and collected liquids from the vacuum extraction system in the soil indicated the presence of CCl_4, and traces of acetonitrile, acetone, chloroform, methylene choride and methane. This indicated that these same substances were also present in the unsaturated zone beneath the tank farm at UMC. Since CCl_4 was the major constituent of the chemicals detected, it is the only chemical that was quantitatively analyzed by UMC in the unsaturated zone and, for the most part, in the saturated zone.

The vacuum extraction system operated in various configurations until it was shut down in March 1988, when analysis of vented soil vapors revealed nondetectable levels of CCl_4 from the vacuum extraction wells. Although the system was successful in removing CCl_4 vapors from the unsaturated zone down to nondetectable levels, the system was not capable of removing CCl_4 which had adsorbed to the soil particles. Given CCl_4's high retardation factor and kinematic viscosity which enables the chemical to exist in the unsaturated zone in a separate, pure liquid phase, it would be expected that some CCl_4 is presently adsorbed to the organic carbon of the blanket sands and will remain a persistent secondary source of contamination as the pure CCl_4 product solubilizes in the water between the soil particles over time and migrates into the aquifer. The amount and location of CCl_4 which presently exists in the unsaturated zone is unknown.

From 1982 to 1987, UMC sampled selected groundwater monitoring and water supply wells for CCl_4 on a regular basis. These data was used to track the movement of contamination resulting from the 1982 spill.

CCl_4 contaminant data from groundwater monitoring wells in the immediate vicinity of the UMC facility showed that concentration levels had decreased significantly since the time of the incident. Monitoring wells 1, 8 and 10 which exhibited the highest concentration levels of CCl_4 in 1983, greater than 30,000 ppb, had decreased to less than 150 ppb in 1987. Natural aquifer flushing and dilution would have contributed to this decrease in concentration levels.

Groundwater data collected from 1982 to 1987 revealed the general direction of the migrating CCl_4 contamination to be north/northwest. The areal extent of the contamination measured in 1987 encompassing concentrations of 5 ppb or greater was approximately 2.1 square miles (see Figure 7).

1988 groundwater samples collected by EPA's contractor, CDM-FPC, were analyzed for Target Compound List (TCL) volatile organics, metals and cyanide through the EPA Contract Laboratory Program. Wells that were sampled are located on Figure 8. Samples collected from stainless steel monitoring wells MW-101, 102 and 103 (constructed in 1987) were analyzed for both TCL metals and dissolved metals.

Results from 1988 data, presented in Table 1, show CCl_4 concentrations exceed the Maximum Contaminant Level (MCL) of 5 ppb for CCl_4, established under the Safe Drinking Water Act, in monitoring wells 1, 16, 18, 21, 22, 23, 101 and Vaqueria Sabana (#305), a stock well. Samples collected from a spring, La Cambija (#52), which feeds into the Cano Tiburones were also found to contain CCl_4 concentrations in excess of 5 ppb. Monitoring wells 16, 18, and 23 contained the highest CCl_4 concentrations of 140, 160 and 170 ppb, respectively. These wells also contained the highest levels of chloroform, although the levels were less than the Puerto Rico Department of Health maximum contaminant level standard for any single organic chemical. Acetonitrile was not detected at any of the sampling locations.

Acetone was detected in groundwater samples from monitoring wells 1, 21, 23 and 101 at corresponding concentrations of 61, 41, 26 and 37 ppb. The fact that acetone was also found in the field blanks, however, indicates this compound may be residual from decontamination of the sampling equipment and, therefore, not indicative of groundwater contamination.

Toluene was detected at 24 ppb in well 48, which is no longer in use as a domestic well. However, this concentration was below the recommended MCL, proposed in the Federal Register on November 13, 1985 pursuant to the Safe Drinking Water Act.

High concentrations of iron, calcium, magnesium, sodium and potassium were detected in many of the wells. These ions are naturally found in carbonate limestone aquifers that are not in contact with salt water.

Arsenic and selenium were found in abandoned well 51, at elevated levels which exceeded primary drinking water standards. In addition, lead concentrations at well 54 exceeded primary drinking water standards. Well 54 is currently used for irrigation purposes. The presence of arsenic, selenium and lead in the groundwater may be attributable to contamination originating from local industries.

Levels of chromium in excess of the MCL of 50 ppb were found at monitoring wells 101, 102 and 103. Dissolved metal concentrations in these wells were, however, considerably lower than the corresponding total metal analysis. Since excessive levels of chromium were only detected in 3 out of 26 locations sampled in January 1988, EPA does not believe that the metals detected (particularly chromium) are necessarily indicative of groundwater contamination. EPA believes that the presence of metals may be attributable to well development. However, it is also possible that chromium may be a result of contamination originating from local industries.

The highest CCl_4 concentrations detected in January 1988 by EPA coincide with the highest concentrations found in 1987 by UMC. Currently, the leading edge of the extent of CCl_4 contamination, however, appears to be located considerably south of the Garrochales #3 well (see Figure 9).

The zone of contamination addressed in the 1988 draft FS report was interpreted by superimposing the yearly maximum CCl_4 concentration gradients from 1983 through 1987 (see Figure 10). This effort has revealed a consistently higher level of CCl_4 contamination in the area between UMC and well #54.

Concentration gradients constructed from the 1988 groundwater data indicate that the major portion of the residual CCl_4 contamination currently existing in the groundwater is within this same zone that has historically revealed the highest CCl_4 concentrations.

Data provided by the United States Geological Survey (USGS) indicate that there are no private wells used for drinking water located within the zone of contamination. Wells within the zone of contamination are located on Figure 11.

Based on the current location of the groundwater wells, the bulk of residual CCl_4 contamination currently existing in the groundwater has been identified within the diffuse component of the flow, to extend approximately 8,500 to 9,500 feet north of the UMC site (see Figure 12).

A small portion of CCl_4 contamination detected in well #305 and in a spring feeding into Cano Tiburones was not evaluated in subsequent remediation schemes since the contamination is already appproaching a point of discharge from the aquifer. At the point of discharge, CCl_4 concentrations are expected to decrease, possibly to less than the MCL of 5 ppb for CCl_4, due to dilution and volatilization of the contaminants.

Pathways of Migration

CCl_4 has a moderate to strong tendency for adsorption to soil particles. Some adsorption of CCl_4 and chloroform to the organic carbon of the blanket sands is expected. The denser-than-water nature of pure CCl_4 liquid may cause the chemical to flow faster than water through the blanket sands and sink through the water table of the Aymamon aquifer. Some degradation of CCl_4 to chloroform is expected.

CCl_4 may remain in the blanket sands or limestone aquifer as a secondary source of contamination as pure liquid, dissolved chemical, or contaminated soil and soil air. As precipitation percolates downward through the blanket sands, CCl_4 may be flushed downward through the sands. This periodic flushing may cause pulses of contamination to enter the aquifer system during rain events.

Most of the acetonitrile probably went into solution in the water between the soil particles with some lost to volatilization and diffusion. Once dissolved, it would have moved through the soil and into the underlying Aymamon aquifer. Little acetonitrile should remain in the soil. That which reached the limestone aquifer may have been flushed relatively rapidly.

Chloroform may exist as a degradation product of CCl_4. Further degradation may occur, but volatilization from soil or groundwater is a more likely removal pathway. Chloroform will not be as retarded by organic matter in soil as CCl_4. It is unlikely that chloroform would exist in a pure liquid state in the blanket soils or Aymamon aquifer.

Groundwater flow in the karstic Aymamon aquifer occurs as a combination of flow through the dissolution channels (conduit flow) within the limestone and flow through the surrounding intact limestone (diffuse flow). Hydrogeological studies conducted in the Barceloneta area indicate that diffuse flow is more prevalent in the immediate area than conduit flow. Because of this, contaminant recovery using groundwater extraction wells is feasible, given properly located wells.

Any contamination present in the groundwater in a dissolution channel will be rapidly transported through the aquifer. Contamination present in the groundwater of the limestone will move much slower. Such differences in velocity and flow direction will spread or disperse contaminants as they move away from a contaminant source.

In addition, the limestone may serve as a reservoir for contaminated water, resulting in a persistent, low level source of contamination to the dissolution channel flow from the limestone, causing a temporal dispersion of the contamination.

Groundwater Characteristics

The aquifer system is dynamic, changing rapidly in flow amount and direction with changes in rainfall amount or pumping. The shift in flow amount or direction may cause widespread dispersion of contaminated water throughout the aquifer. This spatial and temporal dispersion of contaminants leads to difficulties in designing aquifer remediation systems and in estimating aquifer clean up times.

Another significant feature of the water table aquifer is the presence of salt water within the Aymamon and Aguada Formation.

Any remedial activities that include new or increased groundwater pumping must be evaluated in terms of the potential for causing the salt water interface to move further inland.

Salt water encroachment can be expected if pumpage exceeds the natural storage capacity of the aquifer. Also, pumping wells should be designed to avoid local up-coning of salt water beneath the wells. Any pumping of groundwater should include eventual recharge back into the aquifer to maintain the balance of freshwater flow.

The USGS recommends a maximum pumpage limit of the Aymamon limestone aquifer in this area of 6 million gallons per day (mgd) during periods of normal or surplus precipitation to prevent salt water intrusion.

EPA has proposed a groundwater classification system for addressing groundwater use. The unconfined Aymamon/Aguada aquifer has been classified as Class II groundwater. This classification is outlined in "Guidelines for Groundwater Classification under the EPA Groundwater Protection Strategy" - Final Draft (Office of Groundwater Protection WH-550G).

The draft Puerto Rico Groundwater Strategy classifies all groundwater as Class II, unless otherwise demonstrated. For this reason, and due to the fact that the water table aquifer is not irreplaceble, the Class II characteristic (current or potential source of drinking water) is being used. This implies that remediation levels be considered to provide protection of public health and that active restoration of the groundwater be achieved over a reasonable period of time with greater emphasis placed on shorter time frames.

SUMMARY of SITE RISKS

At the UMC site, CCl_4 and acetonitrile were known to be present in the waste stream, and are therefore considered the contaminants of concern for the site. Acetonitrile was not detected at any sampling location in 1988. Chloroform would be expected to be present as a degradation product of CCl_4. Chloroform was detected at only three well locations.

The primary exposure mechanism and public health risk at the UMC site is attributable to the ingestion or other domestic use of contaminated groundwater downgradient from the UMC site. Although the primary exposure route is through ingestion of groundwater, other exposure mechanisms such as inhalation of volatile components during showering, dermal contact during bathing, and inhalation of volatiles released by the air-stripping unit presently operating at the site (for plant workers only) for the UE-1 groundwater extraction well also exist.

Land use in the zone affected by contaminant migration is industrial, agricultural and rural residential. At least several manufacturing plants, the communities of Tiburones and Garrochales, a Job Corps facility and a motel are affected. All users of the unconfined aquifer in the affected zone are potentially endangered. However, as stated previously, according to USGS, no private wells within the zone of contamination currently utilize the groundwater for drinking water purposes. All contaminated and threatened potable wells were shut down shortly after discovery of the spill in 1982. UMC replaced the water supplies to the users of these wells. Artesian well users have not been endangered in the past and the potential for future endangerment is small. The Garrochales #3 well, which replaced the #1 and #2 wells, is currently the only user of the unconfined aquifer for potable water in the affected zone. Private wells located north of the Garrochales #3 well currently use the unconfined aquifer for watering livestock and for irrigation purposes.

Other potentially endangered populations include workers at the UMC plant potentially exposed to contamination through inhalation of vapors from the UE-1 air stripper. Also, users of the Cano Tiburones could potentially be exposed through surface water contact and use.

Ingestion of contaminated fish and contaminated crops (including meat from livestock) are exposure pathways with little potential for adverse human health effects. Concentrations of contaminants and bioconcentration factors for CCl_4 are low, resulting in minimal uptake by fish and crops, thus resulting in a low potential for exposure.

Noncarcinogenic effects associated with ingestion of groundwater and inhalation of volatilized groundwater contaminants were examined through comparison of chronic daily human intake values (an estimated dose which a human receives) to the acceptable intake value for chronic exposure (the estimated dose level believed to be safe). There are unacceptable chronic noncarcinogenic risks for children living in the area affected by the UMC site and ingesting groundwater. For adults, unacceptable risk would be produced by ingestion of groundwater at the AH Robins well. No unacceptable noncarcinogenic risk exists for inhalation of contaminants from the air stripper at the UMC site.

The risk of cancer from exposure to a chemical is described in terms of the probability that an individual exposed for his or her entire lifetime will develop cancer. This value is calculated by multiplying the chronic daily intake by the carcinogenic potency factors reported in the Superfund Public Health Evaluation Manual (USEPA, October 1986). Cancer risks were calculated for the chronic exposures which may occur at the UMC site. These results are presented in Table 2.

The results indicate that chronic ingestion of the groundwater contaminated with CCl_4 would produce unacceptable carcinogenic risks to residents. The risk ranges from 2.3 x 10-4 at the AH Robins well to 5.8 x 10^{-5} at the Cano Tiburones. Plant workers may experience unacceptable carcinogenic risk by breathing volatiles from the on-site air stripper. The risk calculated is 1.6 x 10-5 under specific exposure conditions.

Actual CCl_4 concentrations in the groundwater exceed applicable or relevant and appropriate requirements (ARARs) throughout the affected portion of the unconfined aquifer and in the surface water of the discharge zone. The MCL of 5 ppb for CCl_4 is an ARAR for the site. Levels of CCl_4 in air do not exceed threshold limit values.

The Cano Tiburones, the discharge region of the contaminated aquifer, is a herbaceous wetland area laced with drainage canals. The Cano supports a large population of migratory and native birds and waterfowl. There are sizable fish and aquatic invertebrate populations, with recreational fishing for channel catfish and fresh water shrimp. The Cano Tiburones discharges into Arecibo Bay and the Atlantic Ocean.

Risks to the environment may result from chronic toxic effects of contaminants on aquatic life of the Cano Tiburones. However, currently, the highest amount of CCl_4 detected in the groundwater (at MW-23 during January 1988) is less than the lowest observed effects levels (LOEL) for CCl_4 in freshwater and salt water. Future concentrations of contaminants entering the Cano Tiburones are also expected to be less than the LOEL. Therefore, impacts to aquatic life from existing and future concentrations of contaminants are expected to be low. Risk to terrestrial wildlife is likely to be small, since there is little contact by wildlife with contaminated air or water.

DEVELOPMENT OF ALTERNATIVES

The remedial alternatives for the UMC Site were developed and evaluated using CERCLA, the NCP, a December 24, 1986 memorandum from J. Winston Porter entitled "Interim Guidance On Superfund Selection of Remedy" - OSWER Directive No. 9355.0-19 and the July 24,1987 "Additional Interim Guidance for FY '87 Records of Decision."

A range of potential available remedial technologies were developed that could be used to remediate the site. Remedial technologies involving treatment which permanently and significantly reduces the toxicity, mobility or volume of the hazardous substances as a principal element, are to be preferred over remedial technologies not involving such treatment. These technologies were initially screened on a technical basis.

Initial screening included the following:

- Implementability - constructability and time to achieve cleanup.
- Applicability - physical and chemical suitability for site conditions.

Based on the screening, individual remedial technologies appropriate to site conditions were developed.

Technologies that are not considered appropriate for utilization at the UMC site are listed below.

In-Situ Treatment of Groundwater

- Carbon Adsorption - CCl_4's low molecular weight and low boiling point make carbon adsorption an undesirable treatment technology. In addition, the presence of dissolved solids in the groundwater and the potential for scaling would cause problems in the spent carbon regeneration process which would significantly increase handling costs of the spent carbon.
- Open Basin Aeration - Although this type of air-stripping technology is currently used by UMC for their UE-1 extraction well, it was not recommended for future use because of the lesser degree of control and removal efficiency afforded to the system, when compared with packed column aeration.
- Biodegradation - Biological destruction of the CCl_4 was not recommended because of the required time for metabolization to take place. Because the contamination is in a karstic formation where the groundwater flow moves quickly, the possibility is great that water would reach a potable well before destruction occurred.

- Vacuum Extraction - Applications for vacuum extraction technologies for volatiles removal from the groundwater zone have not been demonstrated based on available literature. The application to saturated-zone volatile removal is expected to be conceptually infeasible because of problems with withdrawal of groundwater into extraction wells and the limited stripping efficiency available because of the relatively small air to water surface interface area compared to other technologies, such as conventional air-stripping towers.

Off-site Groundwater Treatment/Discharge

- Discharge to POTW - Pumping groundwater from extraction wells directly to a treatment plant, from which it is discharged into the ocean, results in net exporting of groundwater from the aquifer. This would cause salt water to intrude into the aquifer, reducing available drinking water supplies, and would create strong institutional and public opposition. As a result, this option is judged to be unfavorable.

Technologies that are considered appropriate for utilization at the UMC site are listed below.

On-site Groundwater Treatment/Discharge

- Air-stripping - This technology has been shown to be an effective method of removing volatile constituents from groundwater. It is a partitioning process in which the volatile organic contaminants are transferred from a dissolved state in the aqueous phase to the air phase through a water to air transfer process. The most widely used method of air stripping is packed column aeration. This type of aeration is recommended for use at the UMC site.

- Pretreatment for Scaling - Problems have been encountered during operation of the air stripper connected to the UE-1 groundwater extraction well. It has been reported that the stripper operates ineffectively as a result of scaling. UMC recently installed, and is presently operating, a pretreatment system to prevent scaling. A liquid polyphosphate scale and corrosion inhibitor, Nalco 7399, is added to the groundwater before treatment. Several other chemicals used for inhibition are available that are approved for use in potable water, should the pretreatment system currently operating need to be replaced. Small scale piloting will then be conducted to determine the most appropriate chemical for the system.

- Reinjection - Reinjection of extracted groundwater must be done to maintain the freshwater/salt water balance of the hydrogeological system to prevent salt water intrusion. Reinjection of the volume of water anticipated is feasible given the porous nature of the karst formation and the thickness of the unsaturated zone.

DESCRIPTION OF ALTERNATIVES

Listed below are descriptions of the four alternatives evaluated in the CDM-FPC FS.

ALTERNATIVE 1 - No Action

This alternative (see Figure 12) involves the cessation of all active pumping to contain or otherwise control the spread of CCl_4 contamination. Well UE-1 would be removed from service and would either be permanently sealed or modified for an alternate use. The Garrochales #3 well would continue to pump at 2000 gallons per minute (gpm) without treatment and would continue to be used as a potable water source. A long-term, rigorous groundwater monitoring program and tracking of the downgradient migration of CCl_4 contamination would be implemented.

By removing well UE-1 from service and terminating the current treatment and recharge of effluent, partial control of the contamination would be eliminated. Contaminants remaining in the unsaturated zone in the immediate area of UE-1 would continue to slowly percolate into the water table. Contaminants already in the groundwater, yet located outside of the effective pumping radius of UE-1, would continue to migrate downgradient in the prevailing direction of groundwater flow. Contaminants currently being removed by UE-1 would also be entrained in the groundwater. A portion of the CCl_4 contamination would be intercepted by Garrochales #3; the remainder of the contamination would eventually discharge into Cano Tiburones, and subsequently, the Atlantic Ocean.

This alternative would not assist in restoring the aquifer. Aquifer restoration would be achieved only through natural flushing and dilution.

CCl_4 concentrations may be expected to decrease as the contaminant mass moves north and is diluted by uncontaminated groundwater. The amount of dilution occuring is difficult to quantify since existing data are insufficient to estimate the vertical extent of the CCl_4 contamination. Whether dilution will be sufficient to reduce bulk contaminant concentrations in the aquifer below the MCL of 5 ppb cannot be determined. The time required to meet the MCL of 5 ppb through natural aquifer flushing cannot be determined since the soil beneath the site may represent a continuing secondary source of CCl_4 contamination, and the persistence of CCl_4 in this type of geological environment is not fully known.

Rigorous groundwater monitoring would be implemented to aid in identifying potential receptors before contamination occurs thereby allowing prudent advance action to be taken in order to minimize potential health risks. Details of the monitoring program would be developed in the remedial design phase.

If pumpage of UE-1 were discontinued, the only remaining principal groundwater withdrawal from the aquifer would be from the Garrochales #3 well which operates at 2.88 mgd which, by itself, is well below the projected 6 mgd safe yield predicted by USGS. Therefore, Alternative 1 would pose no threat of potential salt water encroachment.

Implementation of Alternative 1 involves removing well UE-1 from service. This is expected to take approximately four months.

The institutional constraints posed by Alternative 1 would include licensing requirements for the permanent abandonment and sealing of well UE-1.

The estimated cost breakdown for Alternative 1 is as follows:

Capital:	$ 35,000
O&M :	0
Long-term Groundwater Monitoring:	$440,000
Net Present Worth:	$475,000

Costs for wellhead treatment or alternative water suplies are not included in this alternative.

ALTERNATIVE 2 - Partial Contaminant Control

Under Alternative 2 (see Figure 13), the present operating conditions would be maintained: well UE-1 would continue to pump at 840 gpm, and the Garrochales #3 well would continue to pump at 2000 gpm. In addition, wells UE-1 and Garrochales #3 (not currently treated) would be treated by air stripping.

Treated groundwater from well UE-1 would be discharged into an existing sinkhole located northwest of the UMC facility; treated groundwater from the Garrochales #3 well would continue to serve as a source of potable water. Long-term groundwater monitoring and tracking of the downgradient migration of the CCl_4 contamination would be implemented.

Under this alternative, well UE-1 would continue to provide minimal control of the CCl_4 contamination. The Garrochales #3 well would intercept a portion of the contamination. Contaminants in the aquifer outside the zones of capture of wells UE-1 and Garrochales #3 would continue to migrate to the north towards Cano Tiburones. The highest concentrations of CCl_4, detected north (downgradient) of the zone of capture of well UE-1, could be expected to bypass UE-1 and Garrochales #3 and eventually discharge into Cano Tiburones and the Atlantic Ocean.

Partial aquifer restoration would be achieved under Alternative 2 through pumping and treating wells UE-1 and Garrochales #3. However, because these wells are only capable of controlling a small portion of the contaminants, aquifer restoration would primarily rely on natural aquifer flushing. Dilution of contaminant concentrations would occur as the contamination migrates downgradient. However, the amount of dilution occuring is difficult to quantify since existing data are insufficient to estimate the vertical extent of the CCl_4 contamination. It cannot be determined whether dilution would be sufficient to reduce bulk contaminant concentrations in the groundwater below the MCL of 5 ppb.

The time required to attain the MCL cannot be determined for two reasons: the soil beneath the site may represent a continuing secondary source of CCl_4 contamination, and the persistence of CCl_4 in this type of geologic environment is not fully known.

Alternative 2 represents a net export of groundwater of 3.1 mgd, which is less than the maximum withdrawal rate of 6 mgd, as recommended by USGS. Therefore, this alternative poses no threat of potential salt water encroachment.

Alternative 2 would require upgrading the existing air stripping treatment unit on well UE-1 as well as the installation of a new air-stripping treatment unit on the Garrochales #3 well. This would take approximately two years. Air releases from the treatment units would comply with air emission standards regulated under the Clean Air Act and Rule 419 of the Regulation for Control of Atmospheric Pollution established by the Puerto Rico Environmental Quality Board (PREQB). Due to the high natural hardness and alkalinity of the groundwater, the current aeration system on well UE-1 has encountered significant operating difficulties. This alternative also provides for pretreatment of the extracted groundwater before it enters the aeration system, which would improve the effectiveness and reliability of the system.

The long-term use of the existing wells and upgraded existing and new treatment units would have substantial operation and maintenance requirements.

Groundwater monitoring would be implemented to aid in identifying potential receptors before contamination occurs whereby allowing prudent advance action to be taken in order to minimize potential health risks. Details of the monitoring program would be developed in the remedial design phase.

The estimated cost breakdown for Alternative 2 is as follows:

Capital:	$ 946,000
O&M (30-year present worth)	$ 1,722,000
Long-term Monitoring	$ 440,000
Net Present Worth	$ 3,108,000

ALTERNATIVE 3 - Moderate Contaminant Control

Alternative 3 was developed for the purpose of controlling only the most heavily contaminated portion of the aquifer. This alternative involves continued pumpage, with treatment, of wells UE-1 at 840 gpm, AH Robins at 450 gpm, and Garrochales #3 (previously untreated) at 2000 gpm, with the installation and operation of two new groundwater extraction wells (E-1 and E-2), each operating at 800 gpm (see Figure 14). Under Alternative 3, the Garrochales #3 well would continue to be used as a potable water supply following wellhead treatment; groundwater from wells UE-1 and AH Robins would be treated and discharged to an existing sinkhole located northwest of the UMC facility; the two new extraction wells would also be treated and discharged to that sinkhole. Long-term groundwater monitoring would be implemented. Chloride monitoring wells would be installed to monitor potential salt water encroachment.

The installation of the two new extraction wells would be accomplished using a phased approach, whereby hydrogeological and water quality data from the first well would be evaluated prior to the installation of the second well. This procedure would provide a better understanding of the hydrogeology and would allow for an effective placement of the wells.

The highest concentrations of CCl_4 would be extracted by the two extraction wells, E-1 and E-2, located in the center of the contaminated zone. The recommended locations at which wells E-1 and E-2 would be placed lie in the general area between monitoring wells MW-16 and MW-21, where contaminant concentrations are expected to be greatest. The two new extraction wells, along with the AH Robins well and the UE-1 well, would be expected to remove a significant portion of the most heavily contaminated groundwater. The two new wells are capable of capturing approximately 30% of the total flow across the contaminant zone. However, contaminants present in groundwater downgradient of the two new wells would continue to migrate towards the Garrochales #3 well and the private wells, at concentrations of CCl_4 as high as 170 ppb, as detected at monitoring well MW-23 during the January 1988 sampling event.

Due to the physical barrier posed by the Cambalache State Forest, two air-stripping systems would be required. The first air-stripping system (an upgrade of the existing system) would be located at the UMC property and would receive flow from wells UE-1 (840 gpm), AH Robins (450 gpm), and the two new extraction wells (800 gpm each). The discharge from this treatment system would go to a sinkhole in the vicinity of the UMC plant. The second air stripping system would be located near the Garrochales #3 well and would service only this well (see Figure 15). Both air-stripping systems would include pretreatment. Sufficient land for the second system would have to be acquired and dedicated. The flow from the Garrochales #3 well system would be used for potable purposes.

Air releases from the treatment units would comply with air emission standards regulated under the Clean Air Act and Rule 419 of the Regulation for Control of Atmospheric Pollution, established by PREQB.

A chloride monitoring well network would be constructed downgradient of wells E-1 and E-2 (see Figure 15). The chloride monitoring wells would locate and monitor the shape and migration of the fresh water/salt water interface prior to and during cleanup operations. The exact location of the chloride monitoring well network will be determined during remedial design when sufficient data will be collected to determine the location of the salt water interface.

A long-term groundwater monitoring program would be required for Alternative 3 since a large portion of the contamination would continue to migrate toward Cano Tiburones. Details of the monitoring program would be developed in the remedial design phase.

Alternative 3 would be moderately effective in treating the CCl_4 contamination to concentrations equal to or less than the MCL of 5 ppb. However, since it relies partially on aquifer flushing and partially on pumping and treating at the extraction wells, EPA cannot determine whether the MCL will be attained.

The time required to attain the MCL cannot be estimated since it is expected that the soil contaminated with CCl_4 would continue to represent a persistent secondary source, and the persistence of CCl_4 in this type of geological environment is not fully known.

A well-planned field program is needed in designing a remediation system in the Aymamon aquifer to address both the uncertainties caused by the incomplete data and the complexity of contaminant transport in this karst setting. The extraction well configuration under Alternative 3 would require modification during the predesign stage to optimize CCl_4 capture.

This alternative would require groundwater withdrawals of 7 mgd, which exceed the recommended maximum pumpage limit of the Aymamon limestone of 6 mgd, established by USGS. The potential for salt water intrusion would be substantially reduced by recharging treated groundwater back into the aquifer through an existing sinkhole near the UMC site, as proposed under Alternative 3.

Implementation of Alternative 3 would require upgrading the existing treatment unit on well UE-1, the installation of a new treatment unit on the Garrochales #3 well, the installation of two new extraction wells, chloride monitoring wells, and the development of permanent easements. Subject to the possible applicability of Section 121(e)(1) of CERCLA, permits may be necessary for the chloride monitoring wells. These items are expected to take approximately 2 years to implement.

Moderate institutional constraints would be imposed during implementation of Alternative 3. The installation of water wells would require the services of a drilling contractor meeting the licensing requirements of the Puerto Rico Department of Natural Resources (PRDNR). In addition, permits for the chloride monitoring wells may be required by PRDNR.

The estimated costs of this alternative are as follows:

Capital	\$ 2,205,000
O & M (30-year present worth)	\$ 4,186,000
Long-term Monitoring	\$ 440,000
Net Present Worth	\$ 6,831,000

ALTERNATIVE 4 - Extensive Contaminant Control

This alternative was developed for the purpose of controlling the bulk of residual CCl_4 contamination in the aquifer. Alternative 4 includes continued pumpage, with treatment, of wells UE-1 at 840 gpm, AH Robins at 450 gpm, and Garrochales #3 (currently untreated) at 2000 gpm, with the installation and operation of a network consisting of seven new extraction wells each operating at 1000 gpm (see Figure 16). Under Alternative 4, the Garrochales #3 well would continue to be used as a potable water source following wellhead treatment; groundwater from wells UE-1, AH Robins and E-1, a new well, would be treated and discharged to an existing sinkhole located northwest of the UMC facility; the remaining six extraction wells would be treated and discharged to recharge wells located downgradient of the extraction well network. Long-term groundwater monitoring would be implemented. Chloride monitoring wells would be installed to monitor potential salt water intrusion.

In order to intercept the bulk of the CCl_4 contamination and allow an adequate degree of safety in the system, a well extraction network would be required. The network proposed under Alternative 4 includes the addition of seven new extraction wells. The installation of extraction wells would be accomplished using a phased approach, whereby hydrogeological and water quality data from each well would be evaluated prior to the installation of subsequent wells. In addition to providing a better understanding of the hydrogeology, this procedure might also demonstrate that fewer wells are required to intercept the bulk of contamination.

The recommended zone in which the extraction wells would be placed lies just north of the leading edge of CCl_4 contamination. It is expected that the wells would be located within the zone of contamination by the time the alternative is implemented (estimated at 2.5 years). In addition, an extraction well, E-1, would be placed in the general area between monitoring wells MW-16 and MW-21 where contaminant concentrations are expected to be greatest. The recommended recharge well zone would lie between the extraction well zone and the point of discharge at La Cambija spring. The recharge well zone should not be close enough to the extraction well zone to interfere with the movement of groundwater to the extraction wells. The location of the salt water interface, and therefore, the zone of recharge wells, would be determined more precisely during the design phase. Details as to the placement of the extraction wells depend on groundwater data, flow rate and the extent and location of contamination. These details would also be addressed during the design phase.

Groundwater from this extraction system would first be treated to levels of CCl_4 no greater than the MCL of 5 ppb through the use of two air-stripping systems. The discharge from one treatment system would go to an existing sinkhole in the vicinity of the UMC plant. The discharge from a second treatment unit would be recharged through wells located downgradient of the Garrochales #3 well.

Due to the physical barrier posed by the Cambalache State Forest, two air-stripping systems would be necessary. The first air-stripping system (an upgrade of the existing system) would be located at the UMC property, and would receive flow from wells UE-1 (840 gpm), AH Robins (450 gpm) and extraction well E-1 (1000 gpm). The other system would be in the vicinity of the Garrochales #3 well and would handle flows from the remaining 6 new extraction wells (1000 gpm each) as well as the Garrochales #3 well (2000 gpm) (see Figure 17). Both treatment systems would include pretreatment measures. Sufficient land for the second system would have to be acquired and dedicated. The flow in excess of 2000 gpm that is used for potable purposes would be returned to the aquifer through recharge wells.

Air releases from the treatment systems would comply with air emission standards regulated by the Clean Air Act and Rule 419 of the Regulation for Control of Atmospheric Pollution established by PREQB.

A chloride monitoring well network would be constructed downgradient from the extraction wells proposed under Alternative 4 (see Figure 17). In addition, the extraction wells would be monitored for chloride concentrations to determine if upconing is occurring. The chloride monitoring wells would locate and monitor the shape and migration of the fresh water/salt water interface prior to and during cleanup operations.

The network of seven extraction wells could be capable of providing control of almost the entire CCl_4 contamination exceeding the MCL of 5 ppb. Although there is uncertainty in predicting zones of capture and pumping effectiveness of the wells, the uncertainty is considerably reduced by locating a greater number of wells than the absolute minimum.

A well-planned field program is needed in designing a remediation system in the Aymamon aquifer to address both the uncertainties caused by the incomplete data and the complexity of contaminant transport in this karst setting. Therefore, the well configuration under Alternative 4 would require modifications during the predesign stage to optimize CCl_4 capture.

Long-term groundwater monitoring would be required under this alternative. Details of the monitoring program would be developed in the remedial design phase.

Alternative 4 is significantly more effective relative to all other alternatives considered in terms of its capacity to treat contaminants to concentrations equal to or less than the MCL of 5 ppb. This alternative relies mostly on pumping extraction wells to restore the aquifer, rather than natural flushing.

The time required to attain the MCL of 5ppb for CCl_4 cannot be estimated since it is expected that the soil contaminated with CCl_4 will continue to represent a persistent secondary source, and the persistence of CCl_4 in this type of geological environment is not fully known.

This alternative could potentially require groundwater withdrawals of approximately 14.8 mgd, which exceed the recommended maximum pumpage limit of the Aymamon limestone of 6 mgd, established by USGS. However, the potential for salt water encroachment would be substantially reduced by recharging treated groundwater back into the aquifer through the existing sinkhole and through deep recharge wells.

Alternative 4 would require upgrading the existing air-stripping treatment unit on well UE-1, the installation of a new treatment unit on the Garrochales #3 well, the installation of 7 new extraction wells, recharge wells and chloride monitoring wells, and the development of permanent easements. Subject to the possible applicability of Section 121(e)(1) of CERCLA, permits may be required for the chloride monitoring wells and the recharge wells. These items are expected to take approximately 2.5 years to implement.

Moderate to significant institutional constraints would be imposed during the implementation of Alternative 4. The installation of water wells would require the services of a drilling subcontractor meeting the licensing requirements of the PRDNR. In addition, permits may be required by PRDNR for the chloride monitoring wells and the recharge wells.

The estimated costs of this alternative are as follows:

Capital	$ 6,199,000
O & M (30-year present worth)	$ 7,882,000
Long-term Monitoring	$ 440,000
Net Present Worth	$14,521,000

SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

In this section, the four alternatives are compared against each other in relation to the following nine criteria:

1. Overall protection of human health and the environment;
2. Compliance with ARARs;
3. Long-term effectiveness and permanence;
4. Reduction of toxicity, mobility or volume of hazardous substances;
5. Short-term effectiveness;
6. Implementability;
7. Cost;
8. State acceptance; and
9. Community acceptance.

1. Overall Protection of Human Health and the Environment

Protection of human health and the environment is the central mandate of CERCLA. Alternatives 2, 3 and 4 provide for protection of human health by treating the Garrochales #3 well, as a precautionary measure, to levels meeting the MCL of 5 ppb for CCl_4. These alternatives equally minimize potential risk to human health associated with the consumption of contaminated groundwater from the Garrochales #3 well, currently the only well within the zone of contamination being used for potable water.

Compared to Alternatives 1 and 2, Alternatives 3 and 4 are more protective of the downgradient private wells used for irrigation and livestock, with Alternative 4 providing the most protection. Also, Alternatives 3 and 4 compared to Alternatives 1 and 2 are more protective of unauthorized new potable wells installed within the zone of contamination from potential risk. Unauthorized installations would be in violation of PRDNR permitting regulations. However, their occurrence is possible.

Alternatives 3 and 4 provide for greater protection of the environment than Alternatives 1 and 2 because of the extraction wells proposed under Alternatives 3 and 4, which are capable of removing significant portions of the contaminants from the aquifer, and thereby expediting aquifer restoration. The volume of contaminants entering Cano Tiburones would be significantly reduced under Alternatives 3 and 4. Alternatives 1 and 2 would allow uncontrolled migration of contaminants towards Cano Tiburones. Due to dilution though, contaminant concentrations at that discharge area would be expected to be very low, quite possibly below the MCL of 5 ppb. However, Alternatives 1 and 2, which provide minimal reduction, if any, of contaminants in the aquifer, would leave the aquifer unusable for potable water purposes for a longer period of time. Alternative 4 is capable of providing the most contaminant removal and control of migration, and thereby restoring the aquifer more quickly than the other alternatives.

With respect to environmental degradation due to potential salt water encroachment, Alternatives 1 and 2 compare favorably to Alternatives 3 and 4 because they propose no major changes in the hydrologic balance. Alternatives 3 and 4 require groundwater withdrawals of approximately 7 mgd and 14.8 mgd, respectively, which exceed the recommended maximum pumpage limit of the Aymamon limestone of 6 mgd, established by USGS. However, the potential for salt water intrusion under Alternatives 3 and 4 would be substantially reduced by recharging treated groundwater back into the aquifer. There is less potential for salt water encroachment under Alternative 3 than under Alternative 4 because the net loss of groundwater through evapotranspiration is lower for Alternative 3 since less water is recirculated.

2. Compliance with ARARs

Section 121(d) of CERCLA requires that remedial actions comply with all applicable or relevant and appropriate Federal and State requirements for the hazardous substances, pollutants or contaminants that are present on-site, as well as any action-specific requirements (e.g., design, construction, etc.) and locational requirements.

The air-stripping systems proposed under Alternatives 2, 3, and 4 are equally capable of meeting Federal and State requirements for air emissions. These systems are also equally capable of treating extracted groundwater to levels no greater than the MCL of 5 ppb, before the treated water is either recharged to the aquifer or discharged from the Garrochales #3 well to the PRASA public water supply system.

EPA cannot determine whether complete aquifer restoration (meeting MCLs) in this type of geological setting within a reasonable period of time is possible using the technology of groundwater extraction. Therefore, EPA cannot predict whether the groundwater extraction well systems proposed under Alternatives 3 and 4 would attain the MCL of 5 ppb for CCl_4 and thereby restore the aquifer within a reasonable period of time. Nevertheless, complete aquifer restoration is the long-term objective. Alternatives 1 through 4 will be comparatively evaluated in this section for their potential to meet the ARAR, the MCL of 5 ppb for CCl_4 throughout the aquifer, within a reasonable period of time.

Alternative 1 relies totally on natural aquifer flushing and dilution to reduce CCl_4 contaminant levels in the aquifer to the MCL of 5 ppb. EPA does not believe that natural aquifer flushing will restore the aquifer within a reasonable amount of time. Since pumping well UE-1 has little impact on contaminant removal and control of migration, Alternative 2 relies very heavily on natural aquifer flushing and dilution to reduce contaminant levels to the MCL of 5 ppb. Alternatives 1 and 2 are not expected to be capable of reducing CCl_4 contaminant levels in the aquifer to the MCL of 5 ppb within a reasonable period of time.

Alternative 3 proposes two additional extraction wells, which would be capable of reducing contaminant levels and controlling migration of the most heavily contaminated portions of the aquifer, while allowing some contaminant migration. Alternative 3 relies partially on natural aquifer flushing and partially on pumpage of two extraction wells to reduce contaminant concentration levels in the aquifer to levels meeting the MCL of 5 ppb, and is therefore more capable than Alternatives 1 and 2 of restoring the aquifer within a reasonable period of time.

Alternative 4 proposes a network of seven new extraction wells which would be capable of reducing contaminant levels and controlling migration of the bulk of the residual contamination. Alternative 4 relies mostly on the extraction wells to reduce contaminant concentration levels in the aquifer to the MCL of 5 ppb, and is therefore the most capable of all four alternatives to restore the aquifer within a reasonable period of time.

While it is unclear whether the goal of total aquifer restoration within a reasonable period of time is an attainable one, Alternatives 3 and 4 would at least be capable of attaining the MCL of 5 ppb for CCl_4 in portions of the aquifer.

3. Long-term Effectiveness and Permanence

Long-term effectiveness and permanence addresses the long-term protection and reliability of an alternative. Permanence is a relative term and is therefore expressed in the degree of permanence associated with an alternative with respect to other alternatives being evaluated.

Long-term groundwater monitoring would be implemented for each alternative to measure effectiveness and to identify potential receptors.

Alternatives 2, 3 and 4 all provide for long-term protection of the Garrochales #3 public supply well which minimizes risk associated with consumption of contaminated groundwater by wellhead treatment.

Since Alternatives 1 and 2 provide for only minimal, if any, containment of contaminants in the groundwater near the source, downgradient private wells currently used for watering livestock and irrigation purposes are at a substantial risk of becoming contaminated. Alternatives 3 and 4 are capable of removing more contaminants from the aquifer, and at a faster rate than Alternatives 1 and 2, which rely mostly on dilution and natural aquifer flushing. Therefore, Alternatives 3 and 4 would be more effective at restoring the aquifer and minimizing risk to downgradient private wells.

Alternatives 3 and 4 are much more effective than Alternatives 1 and 2 in terms of the capacity to treat contaminants in the aquifer to concentrations equal to or less than the MCL due to the number of extraction wells and the quantity of water treated and reinjected.

Since pumping well UE-1 has little impact on contaminant migration, it is assumed that CCl_4 would migrate from the UMC site to Cano Tiburones in approximately the same time period under Alternative 2 as it would under Alternative 1. Aquifer restoration under Alternatives 1 and 2 would rely almost totally on natural aquifer flushing.

Although PRDNR currently controls new well installations through its permitting requirements, maintaining these institutional controls for the duration of the aquifer restoration period would be more difficult under Alternatives 1 and 2 than under Alternatives 3 and 4. A greater amount of time is required to cleanse the aquifer through natural aquifer flushing than with the aid of extraction wells. Because of this, future users of the aquifer would be at risk of consumimg higher levels of CCl_4-contaminated groundwater under Alternatives 1 and 2 than they would consume under Alternatives 3 and 4.

While Alternatives 3 and 4 may not be able to attain the MCL of 5 ppb everywhere in the aquifer, these alternatives may provide for attainment of the MCL in some portions of the aquifer, and at the very least, would lessen the potential cancer risk to future users of the aquifer by reducing contaminant levels to a greater extent than they would be reduced by natural flushing.

Alternative 4 would be capable of removing the most contaminants from the aquifer, providing the most control of migration of contaminants, and restoring the aquifer in the shortest period of time, in comparison to Alternatives 1, 2, and 3 and would therefore be the most capable of all the alternatives to meet the MCL in the aquifer.

4. Reduction of Toxicity, Mobility or Volume of Hazardous Substances

This evaluation criterion relates to the performance of a remedial alternative in terms of eliminating or controlling risks associated with the toxicity, mobility or volume of a hazardous substance.

Alternatives 3 and 4 reduce the level of toxicity, volume and mobility of contaminants to a much greater extent than Alternatives 1 and 2. Under Alternative 1, contaminants possibly remaining in the unsaturated zone in the immediate area of well UE-1 would continue to slowly percolate into the water table; contaminants already in the groundwater, yet located outside of the effective pumping radius of well UE-1, would continue to migrate downgradient; and contaminants currently being removed by well UE-1 would also be entrained in the groundwater. As such, the total contaminant volume and mobility would increase by an incremental amount. The toxicity level of CCl_4 would remain unaffected. Alternative 2 slightly reduces the level of toxicity, mobility, and volume of CCl_4 contamination through pumpage and treatment at the UE-1 extraction well.

Under Alternatives 3 and 4, the mobility and volume of CCl_4 in the groundwater are reduced by pumping and treating at the existing wells and proposed extraction wells. The level of toxicity is reduced through treatment. Reducing the level of toxicity in the aquifer will reduce the cancer risk posed to future unauthorized users of the aquifer, should institutional controls fail.

Alternative 4 is capable of providing for the most reduction of toxicity, mobility and volume of contaminants and would remove contaminants from the aquifer the fastest, in comparison to Alternatives 1, 2 and 3.

5. Short-term Effectiveness

The short-term effectiveness criterion measures how well an alternative is expected to perform, the time to achieve performance, and the potential adverse impacts of its implementation.

The time required to meet the MCL of 5 ppb in the aquifer cannot be determined for any of the alternatives due to the fact that the soil beneath the site may represent a persistent secondary source, and also because the persistence of CCl_4 in this type of geological environment is not fully known. However, the time required to meet the MCL would be substantially longer under Alternatives 1 and 2 than under Alternatives 3 and 4, which, in addition to natural aquifer flushing, rely on ground-water extraction wells to actively remove contaminants from the aquifer.

Alternatives 2, 3 and 4 compare equally in the time needed to provide protection to users of the Garrochales #3 well. All three alternatives propose connection of the well to an air-stripping treatment unit.

Implementation of Alternatives 1 and 2 would have very minor short-term impacts to workers and to the environment since little construction would be involved.

Implementation of Alternatives 3 and 4 could pose some risk to workers. Due to the possible release of contaminant vapors during drilling and installation of the wells, workers may be required to use Level C protection. Since the projected work areas are remote from residences or industrial facilities, it is not expected that any contaminant release during construction would affect the general populace. The operation of the ground-water extraction wells would also not be expected to result in an uncontrolled contaminant release.

Under Alternatives 3 and 4, the proposed well locations are somewhat removed from existing roads. This would require land to be cleared and grubbed, and road construction.

Because Alternative 4 involves more construction than Alternative 3, the short-term adverse impacts of Alternative 4 to the environment would be greater.

6. Implementability

Implementability addresses how easy or difficult, feasible or infeasible, it would be to carry out a given alternative. This covers implementation from design through construction and operation and maintenance.

Alternatives 1 and 2 would be relatively easy to implement in comparison to Alternatives 3 and 4. Alternative 1, being the easiest to implement, involves removing well UE-1 from service which would take approximately four months. Operation and maintenance, as well as operator experience, would be minimal.

Alternative 2 would be relatively easy to implement since it only requires upgrading the existing air-stripping treatment unit on well UE-1 and the installation of an air-stripping treatment unit on the Garrochales #3 well, which would take approximately two years. The long-term use of the existing wells and new treatment units would have greater operation and maintenance requirements than would Alternative 1.

Alternatives 1 and 2 would rely on PRDNR more heavily than Alternatives 3 and 4 to maintain control and prevent future well installations in the aquifer for drinking water purposes until complete remediation is achieved.

Alternatives 3 and 4 would be relatively difficult to implement. Both alternatives would have substantially greater operation and maintenance requirements than Alternatives 1 and 2, and would require trained personnel to monitor system behavior and perform routine maintenance.

The proposed extraction well locations in Alternatives 3 and 4 are somewhat removed from existing roads. Additional labor would be required for land clearing and grubbing and road construction. In addition, these alternatives require an extension of electrical utilities.

Moderate to significant institutional constraints would be imposed during the implementation of Alternatives 3 and 4. The installation of water wells would require the services of a drilling subcontractor meeting the licensing requirements of the PRDNR. In addition, permits may be required by PRDNR for chloride monitoring wells proposed under Alternatives 3 and 4, and for recharge wells proposed under Alternative 4, subject to the applicability of Section 121(e)(1) of CERCLA.

Alternative 4 would be the most difficult to implement in comparison to Alternatives 1, 2 and 3, due to the greater number of extaction wells and recharge wells proposed.

The degree of technical implementability would be the same for Alternatives 2, 3 and 4 because the same technologies (groundwater extraction with treatment and recharge to the aquifer) are proposed under each alternative. The equipment and resources under Alternatives 2, 3 and 4 are readily available. Additional extraction wells proposed under Alternatives 3 and 4 would be constructed by the cable tool or dual tube reverse air rotary drilling method, both of which are widely used to construct production wells in this type of limestone.

7. Cost

The cost evaluation of each alternative is based on the capital cost (cost to construct), long-term monitoring, operation and maintenance (O&M), and present worth costs.

Table 3, below, presents the estimates of capital costs, long-term groundwater monitoring costs, O&M costs, and net present worth costs.

TABLE 3 - COST ESTIMATES

ALTER-NATIVE	Capital Costs ($1,000)	Long-Term Groundwater Monitoring ($1,000)	Annual O & M ($1,000)	O&M * 30-year Present Worth ($1,000)	Net Present Worth Cost ($1,000)
1	35	440	-	-	475
2	946	440	151	1,722	3,108
3	2,205	440	368	4,186	6,831
4	6,199	440	691	7,882	14,521

* For costing purposes, O&M was projected to continue for 30 years.

8. State Acceptance

This evaluation criterion addresses the concern and degree of support that the state government has expressed regarding the remedial alternatives being evaluated.

The Commonwealth of Puerto Rico believes that Alternative 3, as modified in the EPA's Proposed Remedial Action Plan, is the most environmentally sound and cost-effective alternative. The Commonwealth is most interested in restoring the aquifer to the maximum extent practicable. A concurrence letter from PREQB (see Attachment 1) is attached to this Record of Decision.

9. Community Acceptance

This evaluation criterion addresses the degree to which members of the local community might support the remedial alternatives being evaluated.

The community expressed opposition to Alternatives 1 and 2, with the exception of UMC, which favored a modified version of Alternative 2 with the replacement of water supplies wherever needed. Alternative 2 would protect the Garrochales #3 well, but would allow contaminants to migrate towards Cano Tiburones. Alternative 1 would neither protect the Garrochales #3 well nor prevent contaminant migration into Cano Tiburones.

The community is in favor of a timely restoration of the aquifer to the maximum extent practicable.

THE SELECTED REMEDY

The overall goal of the cleanup action at the UMC site is to restore the groundwater to its beneficial uses (or health based levels) within a reasonable period of time. However, the EPA is currently unable to select a restoration remedy that it can say with confidence will achieve this goal, because of the unavailability of sufficient information to determine how long it will take to restore the aquifer.

Therefore, the EPA is selecting an interim remedy. The purpose of this interim remedy is to:

- reduce contaminant concentrations and maximize removal of contaminant mass, and
- determine the feasibility of restoring all or portions of the aquifer to health-based levels.

This interim remedy, which is a modified version of Alternative 3, will include the following components:

- Continued pumpage of groundwater extraction well UE-1 at 840 gpm with treatment of the groundwater to levels no greater than 5 ppb of CCL_4 by an upgraded air-stripping system and discharge to an existing sinkhole located northwest of the UMC facility.

- Pumpage of the AH Robins well at 450 gpm plus the installation and pumpage of two new extraction wells each at 800 gpm, with treatment of the groundwater to levels no greater than 5 ppb of CCl_4 by the UE-1 air-stripping system and discharge to the existing sinkhole.
- Continued pumpage of the Garrochales #3 public supply well at 2000 gpm with treatment of the groundwater to levels no greater than 5 ppb of CCl_4 by air-stripping and subsequent distribution to the public water supply system. During remedial design, an evaluation will be made of replacing treated water from the Garrochales #3 well with an alternate water supply from the artesian aquifer. Since the pumpage of the Garrochales #3 well is not an intregal part of the remedial scheme, this well may be taken out of service if an artesian well is installed.
- If the two new extraction wells prove to be effective at removing contaminants from the aquifer, additional extraction wells will be added in a phased approach with treatment by air stripping and recharge to the groundwater. It is estimated that two to four additional wells will be installed and pumped at approximately 800 gpm.
- Installation of chloride monitoring wells near the coastline to monitor potential salt-water encroachment.
- Long-term monitoring of groundwater to track contaminant movement and assess performance of groundwater extraction wells.

In analyzing potential remedies for the site, EPA favored Alternatives 3 and 4 as being more protective of human health and the environment than Alternatives 1 and 2. Evaluation of Alternatives 3 and 4 according to the nine criteria, with emphasis placed on the complex hydrogeological conditions present at the site, lead EPA to select a modified version of Alternative 3 as an interim cleanup remedy for the site.

Alternative 4, with its network of seven extraction wells, is capable of removing the most contaminants, providing for the most control of contaminant migration, and restoring the aquifer the fastest, thereby providing the most protection of human health and the environment of Alternatives 1 through 4. However, due to the complex hydrogeology underlying the site, uncertainties exist regarding the effectiveness of groundwater extraction wells at removing contaminants from the aquifer. Given the costliness of Alternative 4, which is approximately twice the cost of Alternative 3, it is uncertain whether the actual level of contaminant removal would be great enough to justify the cost of the alternative. Therefore, EPA cannot determine that Alternative 4 would be a cost-effective alternative.

On the other hand, Alternative 3, which proposes two extraction wells, is capable of reducing contaminant concentration levels in the most heavily contaminated portions of the aquifer, providing for partial control of contaminant migration, and restoring the aquifer faster than Alternative 1 and 2 which rely almost exclusively on natural flushing and dilution. Also, the cost of Alternative 3 is moderate in relation to Alternative 4. However, Alternative 3 would allow a large portion of contaminants, with CCl_4 concentration levels at least as high as 170 ppb, to migrate towards Cano Tiburones. This alternative is only capable of intercepting approximately thirty percent of the total flow across the contaminant zone.

At this time, EPA believes that the optimal groundwater extraction system for the site consists of a system which is somewhat between Alternatives 3 and 4. EPA, however, cannot determine the optimal number of wells nor predict their effectiveness without first operating the wells. EPA is thereby selecting a modified version of Alternative 3, which includes the installation of additional extraction wells if the two new extraction wells initially installed prove to have an effectiveness, in terms of their removal of contaminants, which is commensurate with the costs of installing, operating and maintaining the wells.

The exact number of additional extraction wells that would be installed if the two new extraction wells installed initially prove to be effective, the pumping rates of these wells, and the exact location of the wells cannot be determined at this time. However, it can be estimated that approximately two to four additional wells may be installed that would pump at approximately 800 gpm each.

EPA believes that the modified Alternative 3 is cost-effective in that extraction wells would be added sequentially, up to a total of approximately four additional wells, aside from the initial two, provided that the wells were shown to be effective or have a high probability of success at removing contaminants from the aquifer. Construction and implementation of the initial groundwater remediation system (upgrading the UE-1 air stripper, installing an air stripper to the Garrochales #3 well and installing two new extraction wells and chloride monitoring wells) is similar in scope to Alternative 3 of the FS. If four additional extraction wells were installed, the expanded remedy would entail a remedy similar in scope to Alternative 4. Therefore, the Selected Interim Remedy is estimated to cost:

	Capital Cost ($K)	Annual O&M ($K)
Initial System	$2,200	$400
Expanded System (Plus Initial System)	$6,200	$700

The effectiveness of the two initial new extraction wells will be assessed based on the CCl_4 concentrations detected in the extraction wells and in existing and future monitoring wells. Additional extraction wells will be added based upon the effectiveness of the two extraction wells initially installed.

Extracted groundwater from the additional wells will be treated by air stripping by either the upgraded treatment unit proposed for well UE-1, or by the new treatment unit proposed for the Garrochales #3 well. These treatment units will be modified, if needed, to handle any additional flow exceeding the capacities of the units. Treated effluent will be discharged into the aquifer either through the existing sinkhole or through deep recharge wells.

Each extraction well, including UE-1 and AH Robins, with the exception of Garrochales #3, will operate until CCl_4 levels have stabilized and are not being reduced. Once this is achieved, pumping will be discontinued at the well and the well will be monitored for a period of time. The contaminant concentration levels are expected to rise within these wells after a period of nonpumping, or resting, at which time pumping of the well will be resumed. This cycle of pumping and resting will continue for each extraction well until it is determined that contaminant levels in the extraction wells are not rising above the MCL of 5 ppb after successive resting periods. However, since it is not known whether contaminant levels in the aquifer can be reduced to the MCL, EPA will reevaluate this remedy within five years of operation (should the contaminant levels in the aquifer not meet the MCL within this time period) to determine the allowable contaminant levels that the extraction wells must meet before being shut down.

As stated above, operation of the extraction wells will continue for approximately 5 years at which time a full remedy evaluation will be conducted. The purpose of this evaluation would be to determine the practicability and cost-effectiveness of cleaning up all or part of the aquifer and to specify the type of further action to be taken. If a decision is made that any portion of the aquifer will not be restored, then a waiver from the MCL for reasons of technical impracticability will be evaluated at that time.

It is expected that some CCl_4 has remained adsorbed to the organic carbon in the unsaturated zone and will remain a secondary source of contamination to the groundwater as the pure CCl_4 solubilizes in the water between the soil particles over time. The amount and location of residual CCl_4 which presently exists in the unsaturated zone is unknown. The possible residual contamination of the unsaturated zone and its likelihood as a source will be addressed separately by EPA's

RCRA program, which may require further investigation and response. Therefore, the scope of the Selected Interim Remedy will not address possible contamination of the unsaturated zone.

THE STATUTORY DETERMINATIONS

Protection of Human Health and the Environment

Drinking water in the Barceloneta area is currently provided by the PRASA public supply system. Impacted and threatened water supply wells were shut down shortly after the discovery of the spill in 1982. According to USGS, no private domestic wells within the zone of contamination are currently being used for drinking purposes. However, private wells currently utilize site groundwater for watering livestock and irrigation.

The only well at the site currently being used for potable water is the Garrochales #3 public water supply well. Historic as well as recent sampling of this well indicates the presence of CCl_4 at levels less than the MCL of 5 ppb. There is the possibility, however, that CCl_4 levels exceeding 5 ppb will appear at the Garrochales #3 well in the future.

The Selected Interim Remedy will prevent potential risk of ingestion of contaminated groundwater with wellhead treatment at the Garrochales #3 well. This well will be treated, as a precautionary measure, to levels no greater than the MCL of 5 ppb before the water is distributed through the PRASA public water supply system.

The proposed groundwater extraction wells are capable of removing contaminant mass from the aquifer, thereby reducing contaminant concentration levels, and will provide for at least partial control of contaminant migration. The first two extraction wells to be installed are capable of controlling and reducing contaminant levels of the most heavily contaminated portion of the aquifer. Contaminants not controlled by the proposed extraction wells (either the initial two or the additional wells) will migrate towards Cano Tiburones. However, dilution is expected to reduce contaminant concentrations to low levels by the time that the contaminants reach their discharge point from the aquifer.

The Selected Interim Remedy will provide for protection of human health and the environment through its capability to remove contaminant mass and reduce contaminant concentration levels within the aquifer. A reduction of CCl_4 contaminant concentration levels will result in the following measures protective of human health and the environment:

- reduction of cancer risk levels which will decrease the reliance on institutional controls over future potable well installations in the aquifer,

- protection of presently unimpacted portions of the aquifer (CCl_4 contaminant levels less than the MCL of 5 ppb),
- prevention of further contamination of presently impacted portions of the aquifer,
- a possible attainment of the MCL of 5 ppb for CCl_4 in large portions of the existing impacted areas, and
- reduction of risk to Cano Tiburones and the life it supports.

The Selected Interim Remedy is not expected to cause any adverse short-term or cross-media impacts.

Attainment of ARARs

Table 4 lists both Federal and State potential ARARs as well as criteria, guidances and advisories which were considered for groundwater cleanup.

MCLs, established pursuant to the Safe Drinking Water Act, are legally enforceable standards for drinking water. EPA considers the MCL for CCl_4 of 5 ppb to be a relevant and appropriate requirement with respect to the groundwater at the site and an applicable requirement at the tap.

Water to be distributed to the PRASA public supply system must meet the MCL of 5 ppb for CCl_4. Water to be recharged into the aquifer either through recharge wells or natural sinkholes should also contain CCl_4 levels no greater than the MCL of 5 ppb.

An additional ARAR to be met is Air Emission Standards, regulated under the Clean Air Act. Air-stripping volatiles from the extracted groundwater requires controls pursuant to Rule 419 of the Regulation for Control of Atmospheric Pollution, established by PREQB. This rule limits the rate of discharge of volatile organic contaminants (VOCs) into the atmosphere to 3 pounds per hour or 15 pounds per day (based on mass balance) whichever is less. Off-gas treatment will be required for the air-stripping systems operated under the Selected Interim Remedy if VOC concentrations exceed these limits.

Groundwater leaving the proposed air-stripping systems will meet the MCL of 5 ppb of CCl_4 before being recharged back into the aquifer and before being distributed through the PRASA public water supply system. Air emissions from the treatment units are not expected to exceed PREQB limits. However, if they should, off-gas treatment will be implemented.

Due to the unknowns associated with the underlying geology which may limit the effectiveness of groundwater contaminant recovery extraction wells, and due to the possibility of a persistent source of contaminants existing in the unsaturated zone, EPA cannot determine at this time whether the Selected Interim Remedy will attain the ARAR, the MCL of 5 ppb for CCl_4, in the aquifer within a reasonable period of time. The Selected Interim Remedy may be able to attain the MCL in portions of the aquifer. However, because of this uncertainty, the Selected Interim Remedy will be reevaluated within a five-year operational period.

The Selected Interim Remedy is expected to remove contaminant mass from the aquifer and partially control contaminant migration. The Selected Interim Remedy is capable of restoring the aquifer to a larger extent and in a shorter time period than if the aquifer were allowed to flush by natural means.

Cost-Effectiveness

EPA believes that the Selected Interim Remedy provides overall effectiveness proportionate to its costs. The Selected Interim Remedy will be designed to maximize the removal of contaminant mass from the aquifer. Whether the Selected Interim Remedy can completely or partially restore the aquifer within a reasonable period of time cannot be determined at this time. However, EPA believes the benefits in terms of protection of human health and the environment which can be attained strictly through contaminant mass removal are worth the costs involved.

Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable

For the reasons specified in the Selected Remedy section, the modified version of Alternative 3, as an interim remedy, represents the best balance of the nine criteria and is determined to be the most appropriate remedy for the site at this time. The Selected Interim Remedy utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable.

Preference for Treatment as a Principal Element

The Selected Interim Remedy satisfies the statutory preference for remedies employing treatment that permanently and significantly reduces the toxicity, mobility or volume of hazardous substances. The Selected Remedy includes the installation and operation of groundwater extraction wells for contaminant recovery. Contaminated groundwater pumped from the extraction wells will be treated with air-stripping units before being recharged into the aquifer and before being distributed through the PRASA public water supply system. This pumping and treatment of the groundwater is expected to permanently and significantly reduce the toxicity, mobility and volume of the hazardous substances in the groundwater at the site.

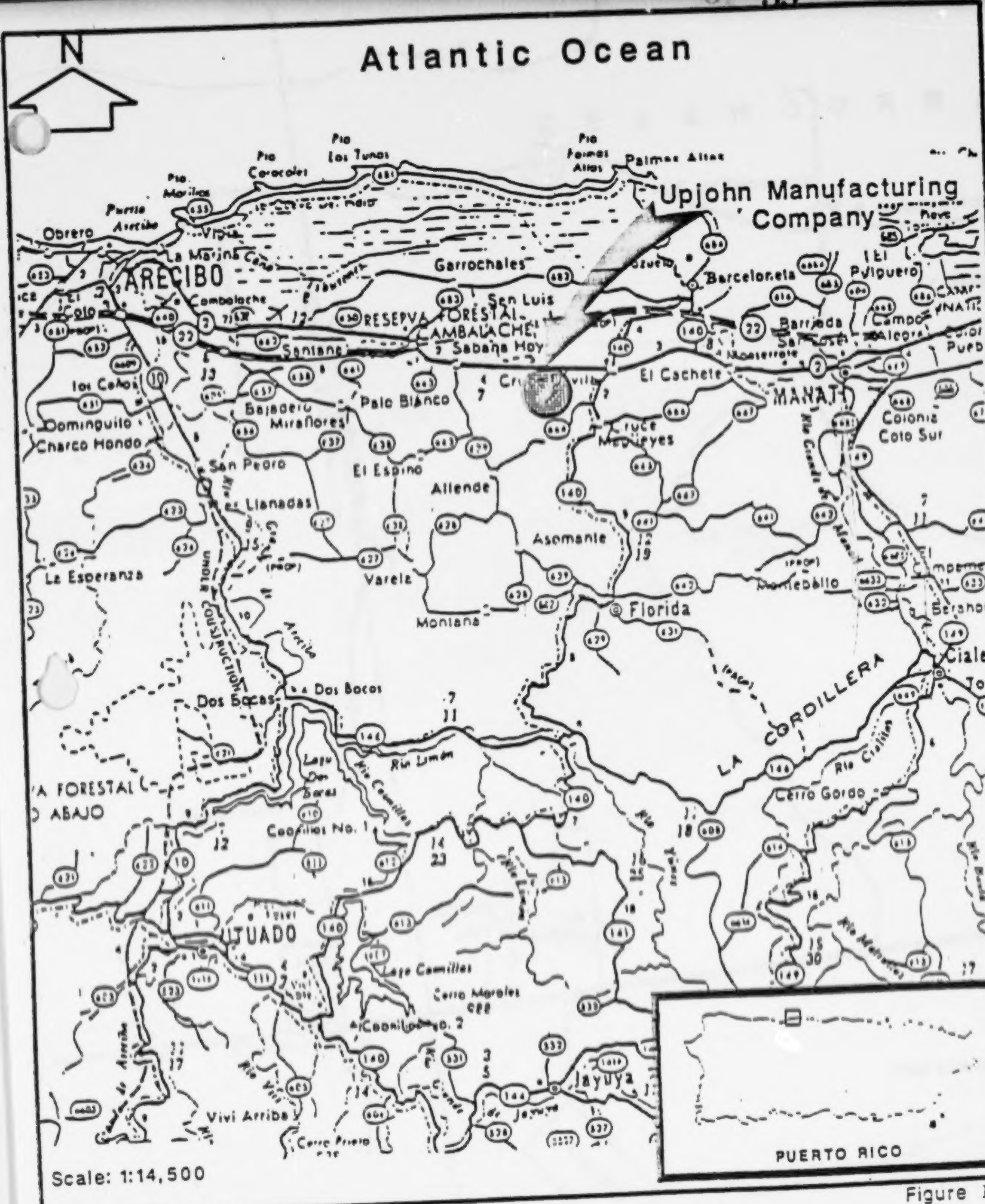
N
Atlantic Ocean
Upjohn Manufacturing Company
Palmas Altas
Arecibo
ARECIBO
Garrochales
San Luis
Barceloneta
RESERVA FORESTAL CAMBALACHE
Sabana Hoy
El Cachete
MANATI
Palo Blanco
Miraflores
San Pedro
Llanadas
El Espino
Allende
Asomante
Varela
Montana
Florida
La Esperanza
Dos Bocas
Rio Limon
LA CORDILLERA
Ciales
Cerro Gordo
Caonillas No. 1
UTUADO
Lago Caonillas
Cerro Morales
Vivi Arriba
Jayuya
PUERTO RICO
Scale: 1:14,500

Figure 1

Location Plan

Upjohn Manufacturing Company
Barceloneta, Puerto Rico

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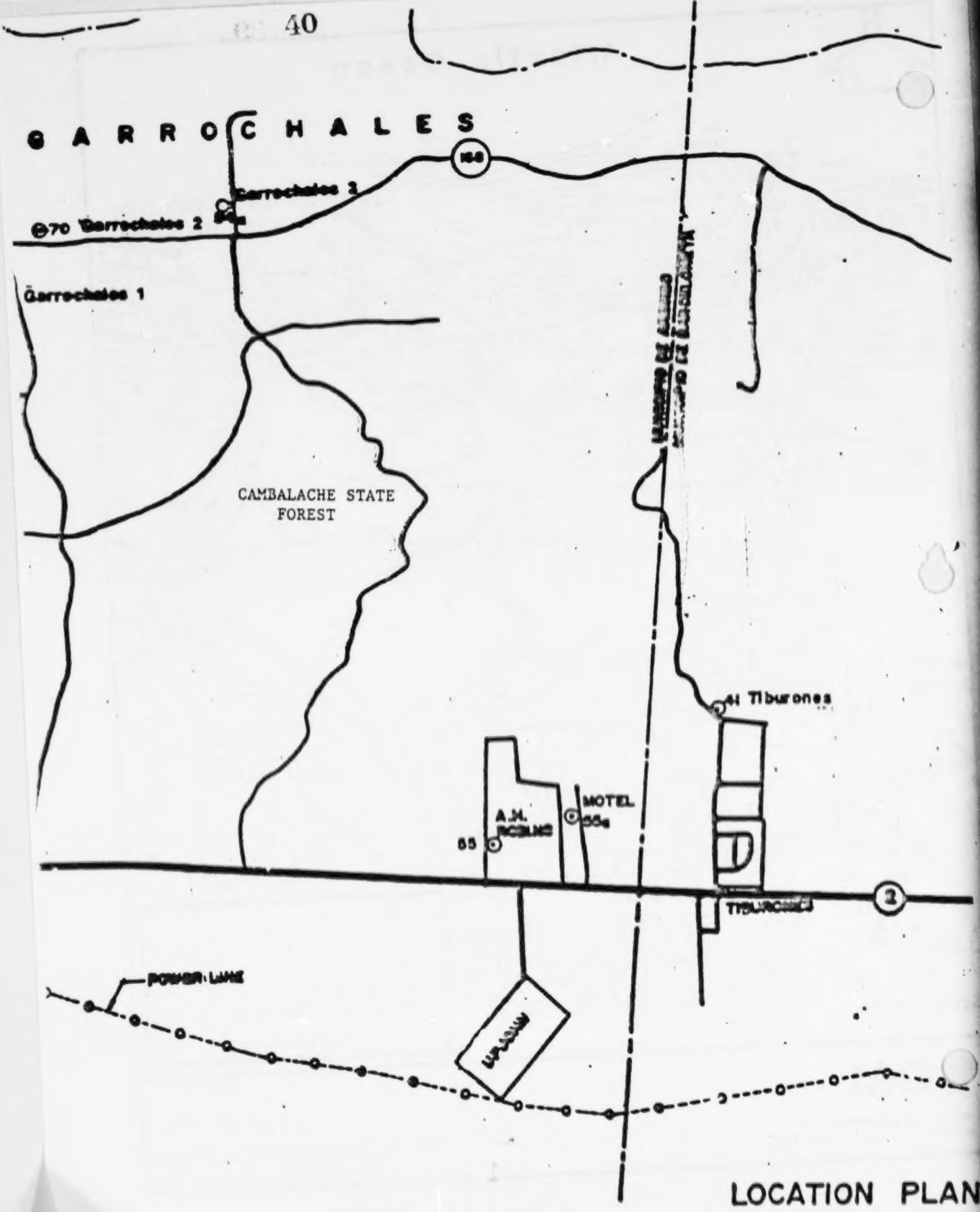
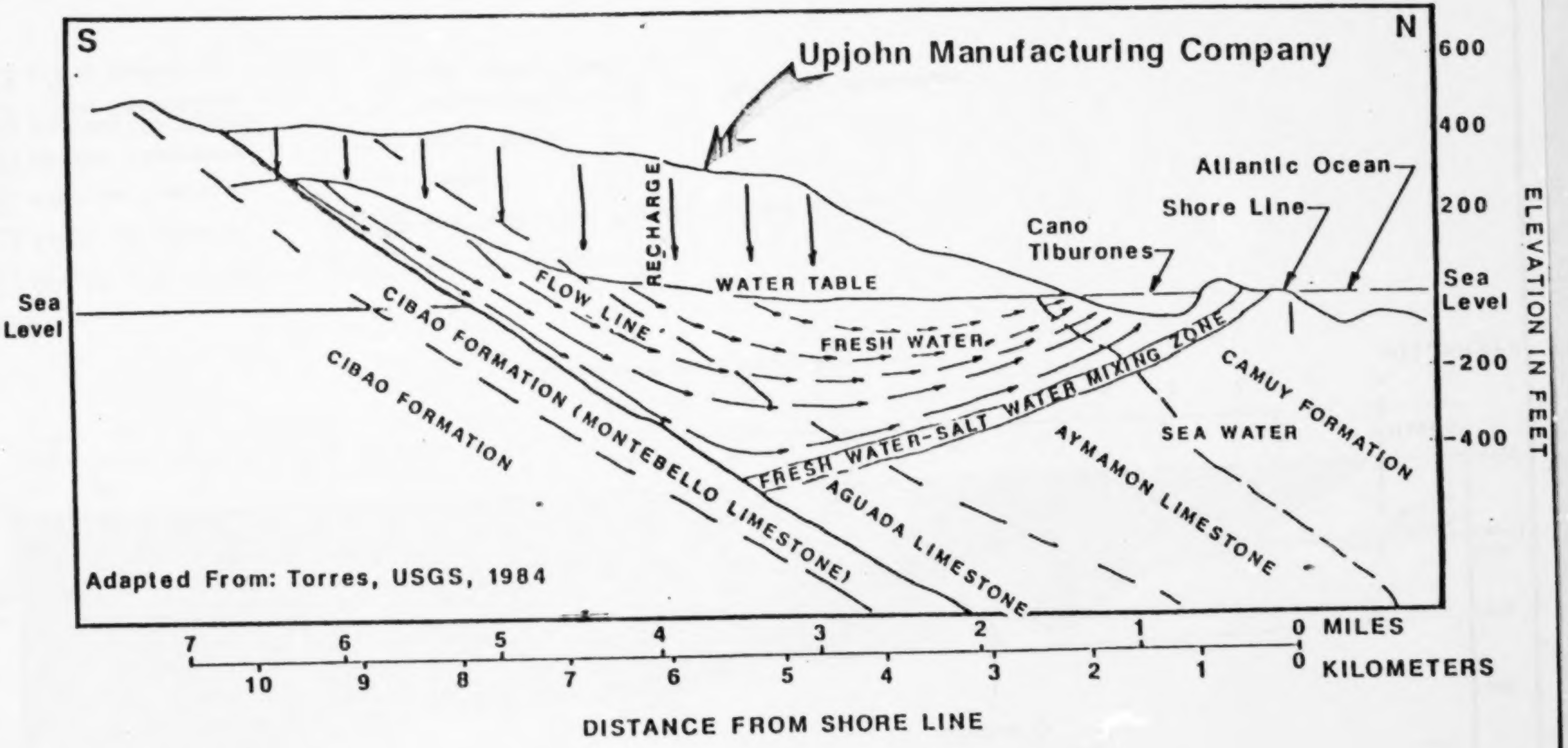
Reproduced from best available copy.


GARROCHALES
Garrochales 3
70 Garrochales 2
Garrochales 1
CAMBALACHE STATE FOREST
41 Tiburones
MOTEL
55a
A.H.
65
2
POWER LINE

LOCATION PLAN

FIGURE 2


S
N
Upjohn Manufacturing Company
Atlantic Ocean
Shore Line
Cano Tiburones
RECHARGE
WATER TABLE
FLOW LINE
FRESH WATER
FRESH WATER-SALT WATER MIXING ZONE
SEA WATER
CAMUY FORMATION
AYMAMON LIMESTONE
AGUADA LIMESTONE
CIBAO FORMATION (MONTEBELLO LIMESTONE)
CIBAO FORMATION
Sea Level
600
400
200
Sea Level
-200
-400
ELEVATION IN FEET
7
6
5
4
3
2
1
0 MILES
10
9
8
7
6
5
4
3
2
1
0 KILOMETERS
DISTANCE FROM SHORE LINE

Adapted From: Torres, USGS, 1984

SOURCE: Modified From Geotec, 1984

Figure 3
Generalized Ground Water Movement Across North–South Cross-Section Through Upjohn Manufacturing Company

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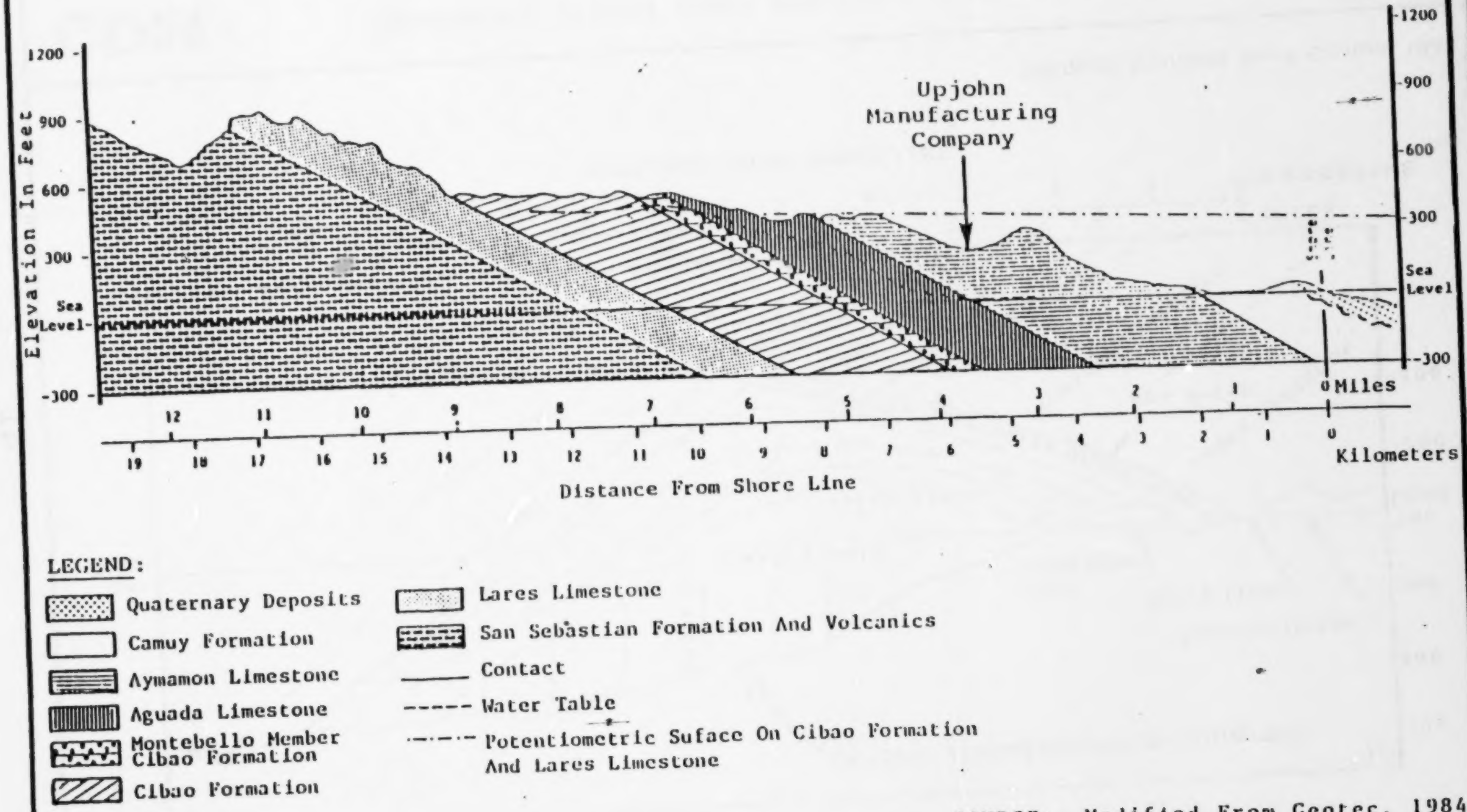
Upjohn Manufacturing Company
Barce eta, Puerto Rico


Upjohn Manufacturing Company
Elevation In Feet
1200
900
600
300
Sea Level
-300
Miles
Kilometers
Distance From Shore Line
LEGEND:
Quaternary Deposits
Camuy Formation
Aymamon Limestone
Aguada Limestone
Montebello Member Cibao Formation
Cibao Formation
Lares Limestone
San Sebastian Formation And Volcanics
Contact
Water Table
Potentiometric Suface On Cibao Formation And Lares Limestone

SOURCE: Modified From Geotec, 1984

Figure 4

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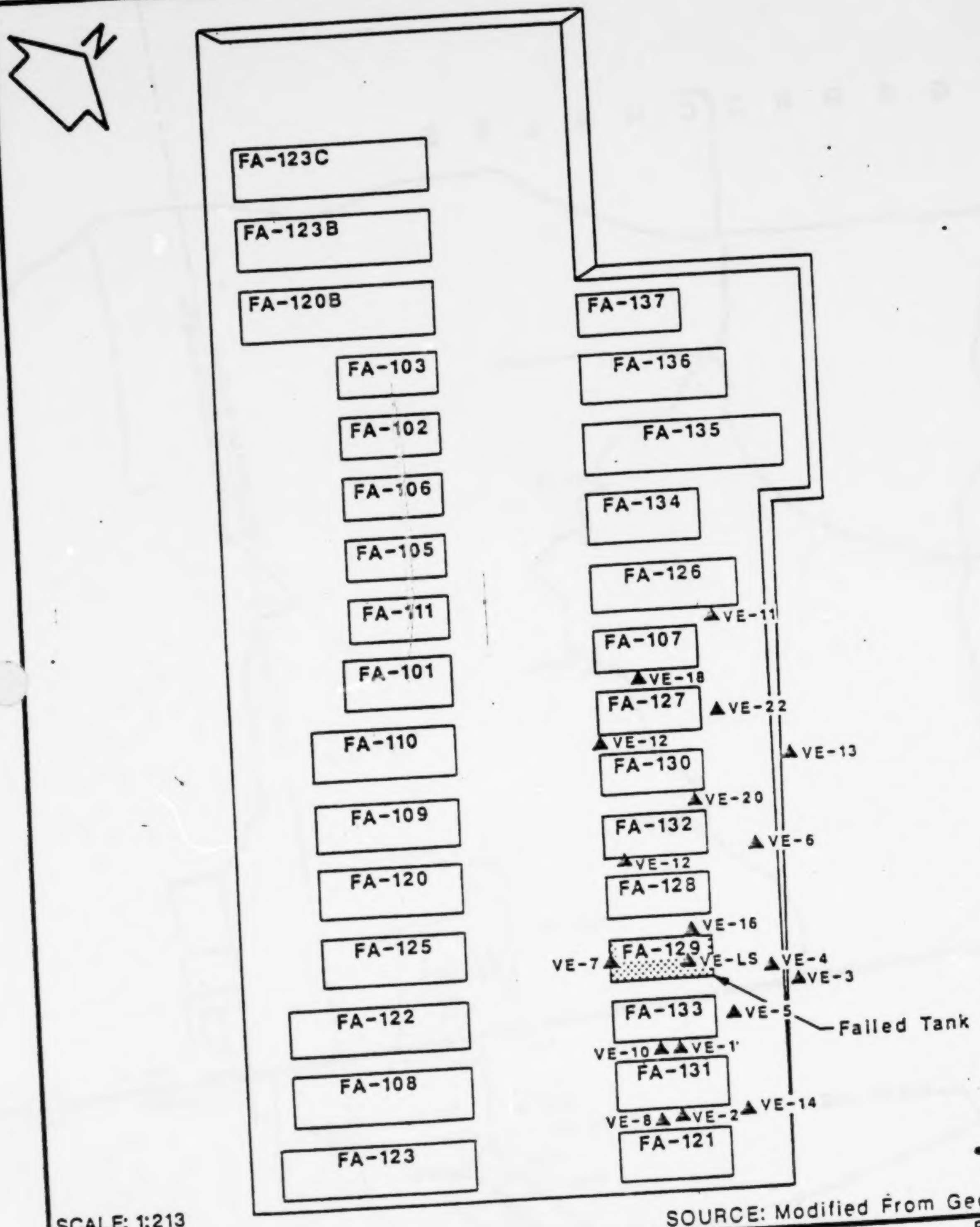
Geologic Sequence

Upjohn Manufacturing Company
Barceloneta, Puerto Rico


N
FA-123C
FA-123B
FA-120B
FA-103
FA-102
FA-106
FA-105
FA-111
FA-101
FA-110
FA-109
FA-120
FA-125
FA-122
FA-108
FA-123
FA-137
FA-136
FA-135
FA-134
FA-126
VE-11
FA-107
VE-18
FA-127
VE-22
VE-12
VE-13
FA-130
VE-20
FA-132
VE-6
VE-12
FA-128
VE-16
FA-129
VE-7
VE-LS
VE-4
VE-3
FA-133
VE-5
Failed Tank
VE-10
VE-1
FA-131
VE-14
VE-8
VE-2
FA-121

SCALE: 1:213

SOURCE: Modified From Geotec, 1984

Figure 5

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Vacuum Well Locations Within Tank Farm

Upjohn Manufacturing Company
Barceloneta, Puerto Rico

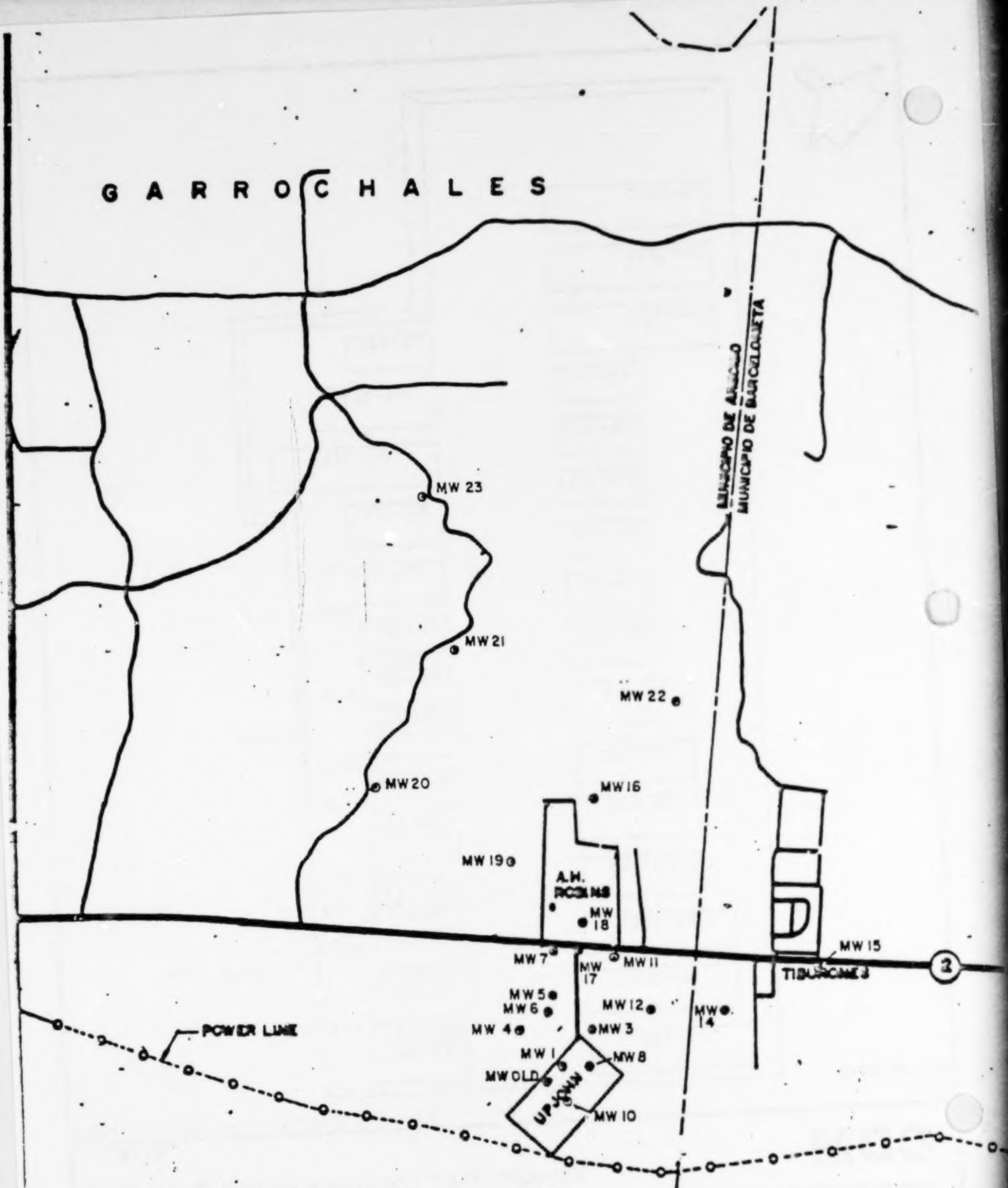
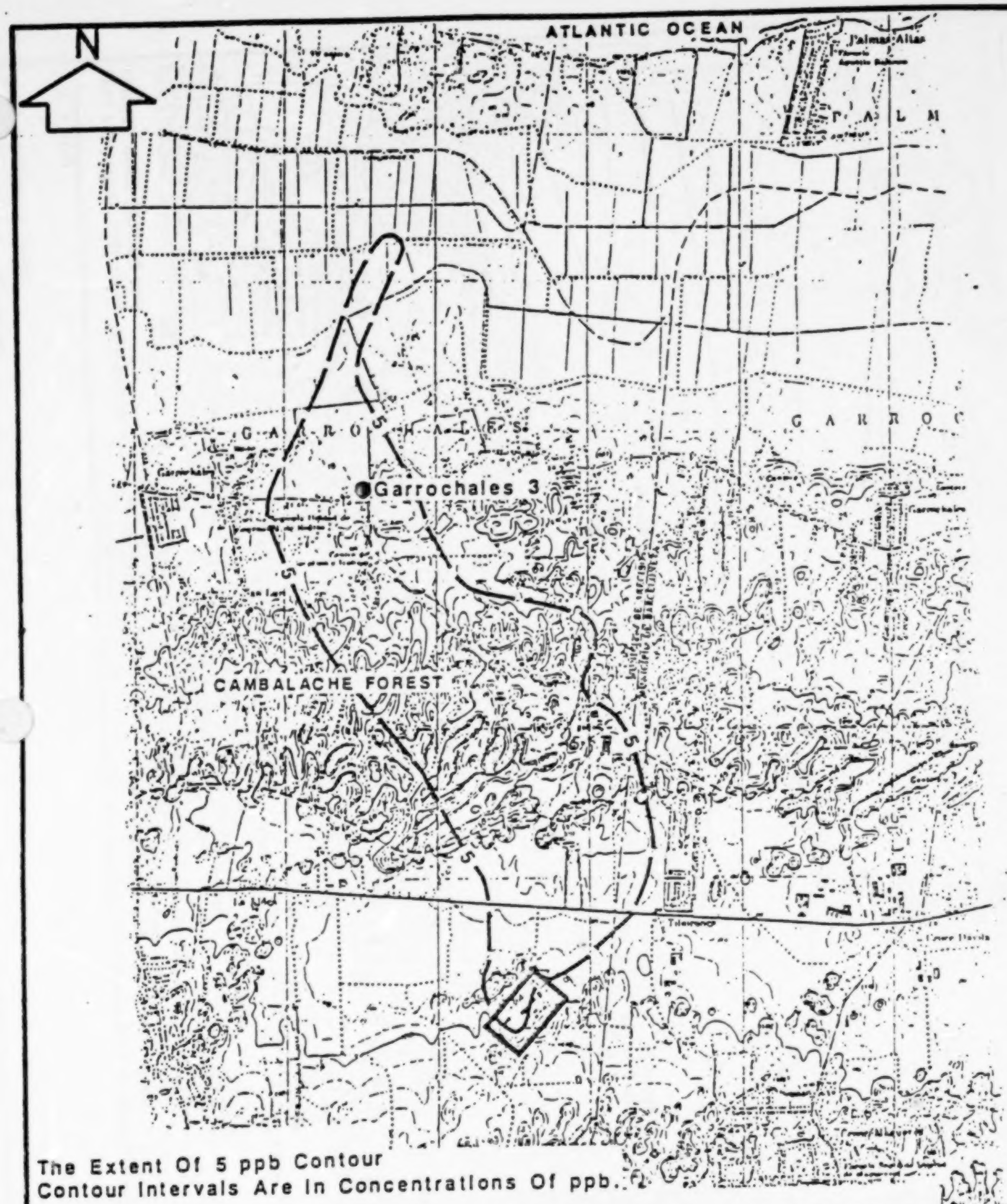

GARROCHALES
MUNICIPIO DE ARECIBO
MUNICIPIO DE BARCELONETA
MW 23
MW 21
MW 22
MW 20
MW 16
MW 19
A.H. ROBINS
MW 18
MW 7
MW 11
MW 17
MW 15
TIBURONES
2
MW 5
MW 6
MW 12
MW 14
MW 4
MW 3
POWER LINE
MW 1
MW 8
MW OLD
UPJOHN
MW 10
FEET
1000
0
1000
2000
3000
KILOMETERS

FIGURE 6


N
ATLANTIC OCEAN
Palmas Altas
P A L M
G A R R O C H A L E S
G A R R O C
Garrochales 3
CAMBALACHE FOREST
5
5
5
5
5

The Extent Of 5 ppb Contour
Contour Intervals Are In Concentrations Of ppb.

1000 0 1000 2000
scale feet

MAP SOURCE: USGS 1:20,000
Barceloneta, Puerto Rico, Quadrangle 1982

Figure 7

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Interpreted Limit Of CCl_4 Contamination, 1987
Upjohn Manufacturing Company
Barceloneta, Puerto Rico

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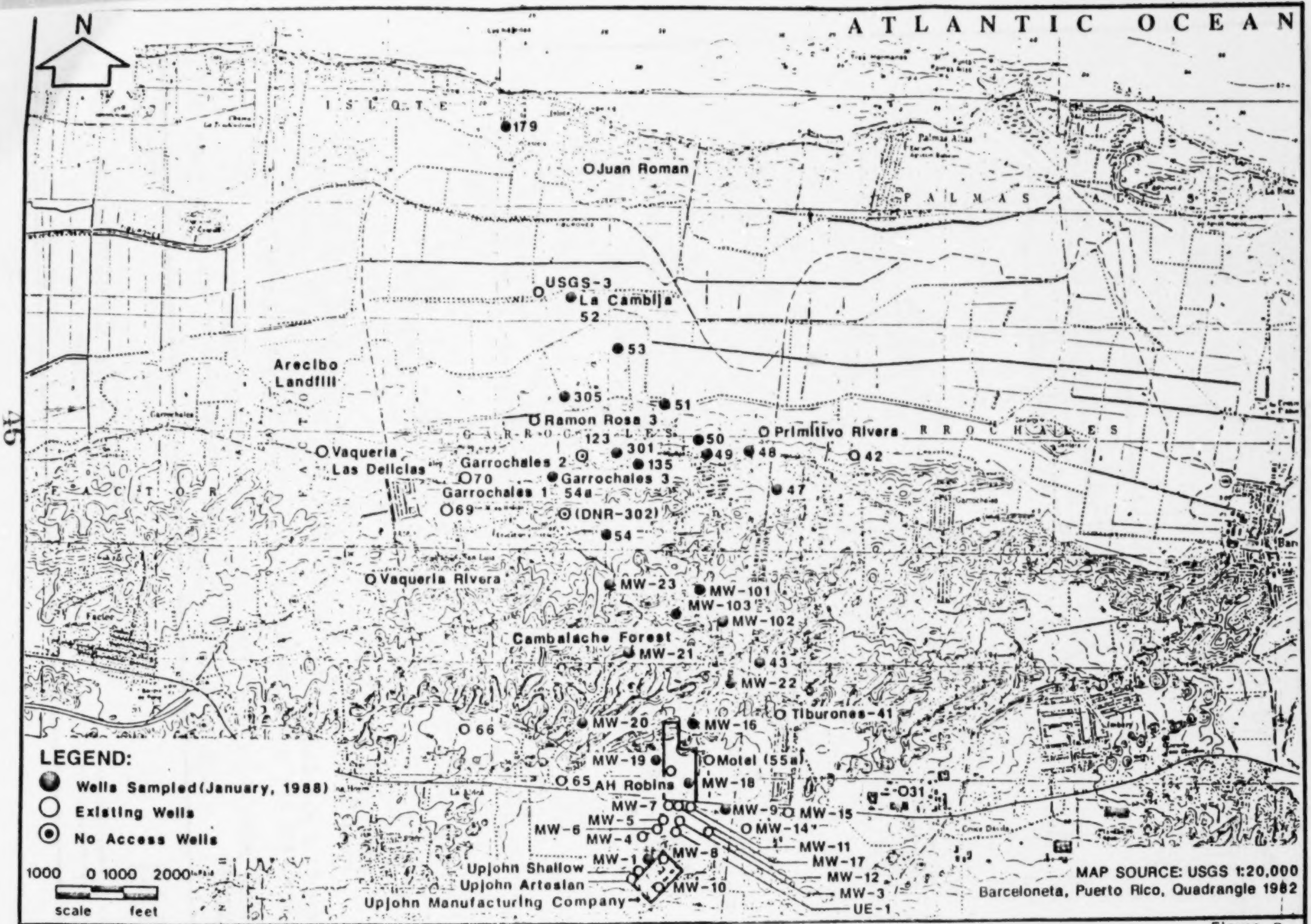
N
ATLANTIC OCEAN
ISLOTE
179
Juan Roman
PALMAS ALTAS
USGS-3
La Cambija
52
53
Arecibo Landfill
305
51
Ramon Rosa 3
GARROCHALES
123
50
Primitivo Rivera
Vaquería Las Delicias
Garrochales 2
301
49
48
42
135
70
Garrochales 3
Garrochales 1
54a
47
69
(DNR-302)
FACTOR
54
Vaqueria Rivera
MW-23
MW-101
MW-103
MW-102
Cambalache Forest
MW-21
43
MW-22
Tiburones-41
66
MW-20
MW-16
MW-19
Motel (55a)
65
AH Robins
MW-18
031
MW-7
MW-9
MW-15
MW-6
MW-5
MW-14
MW-4
MW-11
MW-1
MW-8
MW-17
Upjohn Shallow
MW-12
Upjohn Artesian
MW-10
MW-3
Upjohn Manufacturing Company
UE-1
LEGEND:
● Wells Sampled (January, 1988)
○ Existing Wells
⊙ No Access Wells
1000 0 1000 2000
scale feet
MAP SOURCE: USGS 1:20,000
Barceloneta, Puerto Rico, Quadrangle 1982

Figure 8

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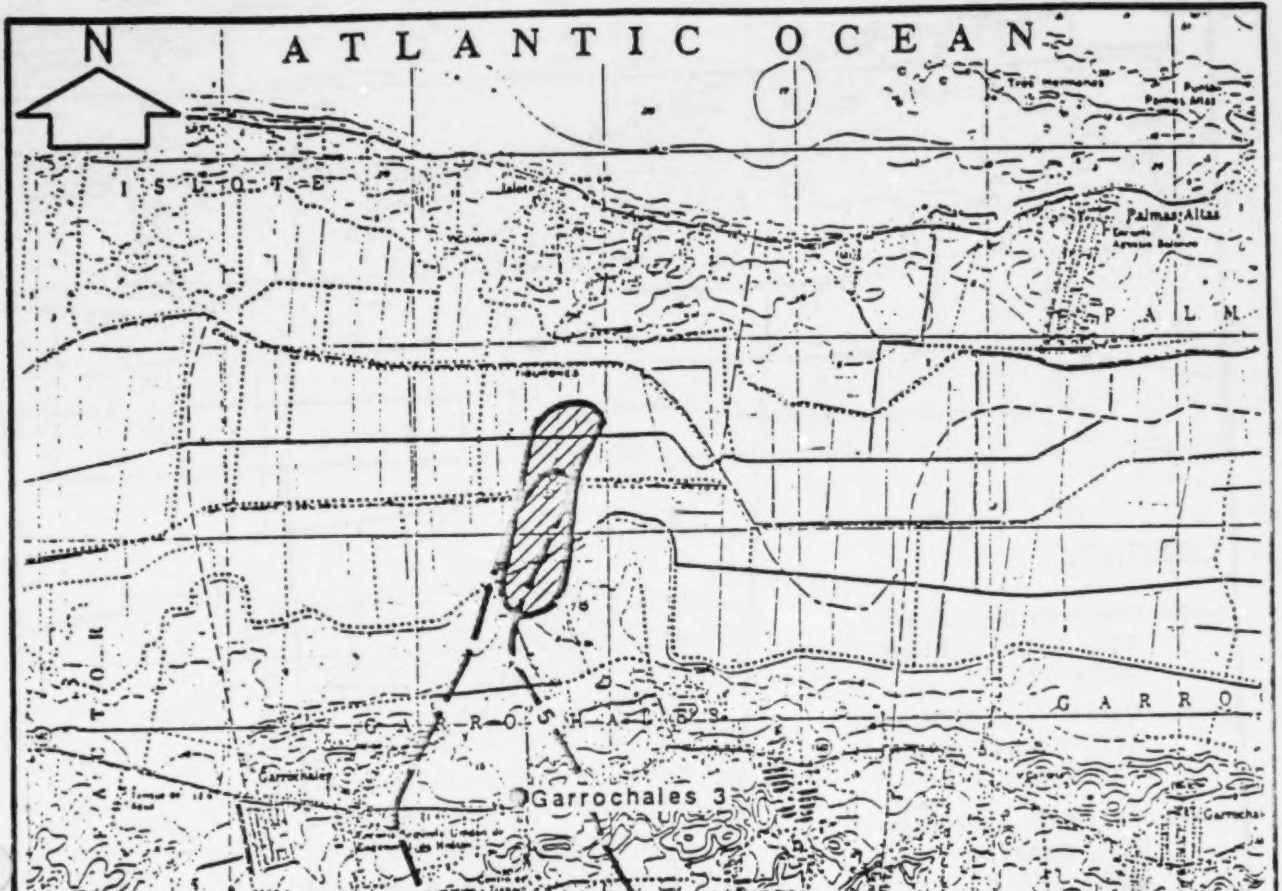
Well Location Map

Upjohn Manufacturing Company
Barceloneta, Puerto Rico


N
ATLANTIC OCEAN
Tres Hermanos
Punta Palmas Altas
ISLOTE
Islote
Palmas Altas
PALM
GARROCHALES
GARRO
Garrochales
Garrochales 3
5
LEGEND:
▨ Represents CCl4 Concentrations ≥ 5 ppb in 1988
⌐ ¬ Interpreted Limit Of 5ppb CCl4 Concentration (1987)
1000 0 1000 2000
scale feet
Tiburones
Upjohn Manufacturing Company

MAP SOURCE: USGS 1:20,000
Barceloneta, Puerto Rico, Quadrangle 1982

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Figure 9
A Comparison Of The 1987 And 1988 Interpreted Limits Of CCl4 Contamination
Upjohn Manufacturing Company
Barceloneta, Puerto Rico

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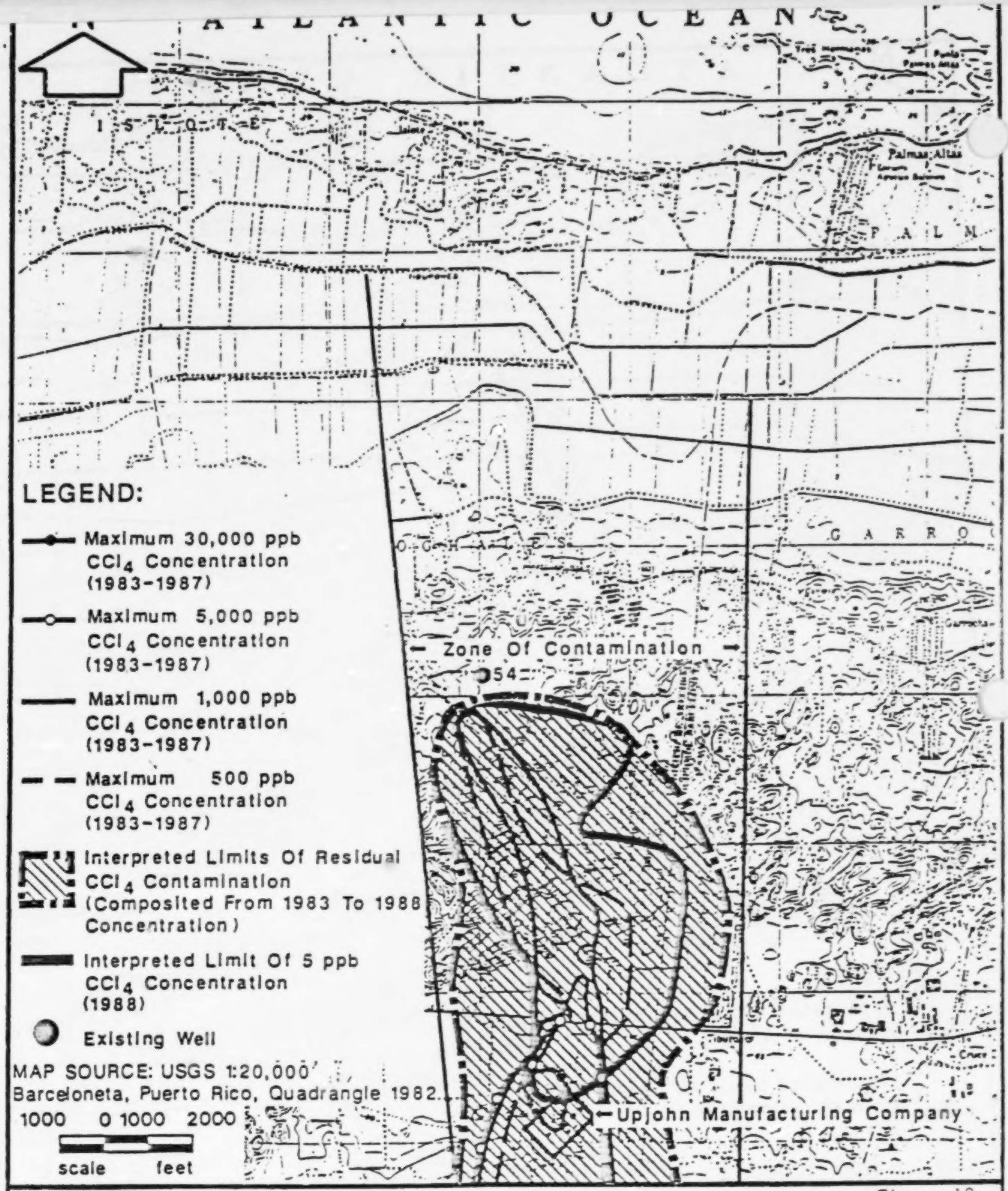
N
ATLANTIC OCEAN
ISLOTE
Palmas Altas
PALM
GARRO
OCHALES
LEGEND:
Maximum 30,000 ppb CCl4 Concentration (1983-1987)
Maximum 5,000 ppb CCl4 Concentration (1983-1987)
Maximum 1,000 ppb CCl4 Concentration (1983-1987)
Maximum 500 ppb CCl4 Concentration (1983-1987)
Interpreted Limits Of Residual CCl4 Contamination (Composited From 1983 To 1988 Concentration)
Interpreted Limit Of 5 ppb CCl4 Concentration (1988)
Existing Well
Zone Of Contamination
54
Upjohn Manufacturing Company
MAP SOURCE: USGS 1:20,000
Barceloneta, Puerto Rico, Quadrangle 1982
1000 0 1000 2000
scale feet

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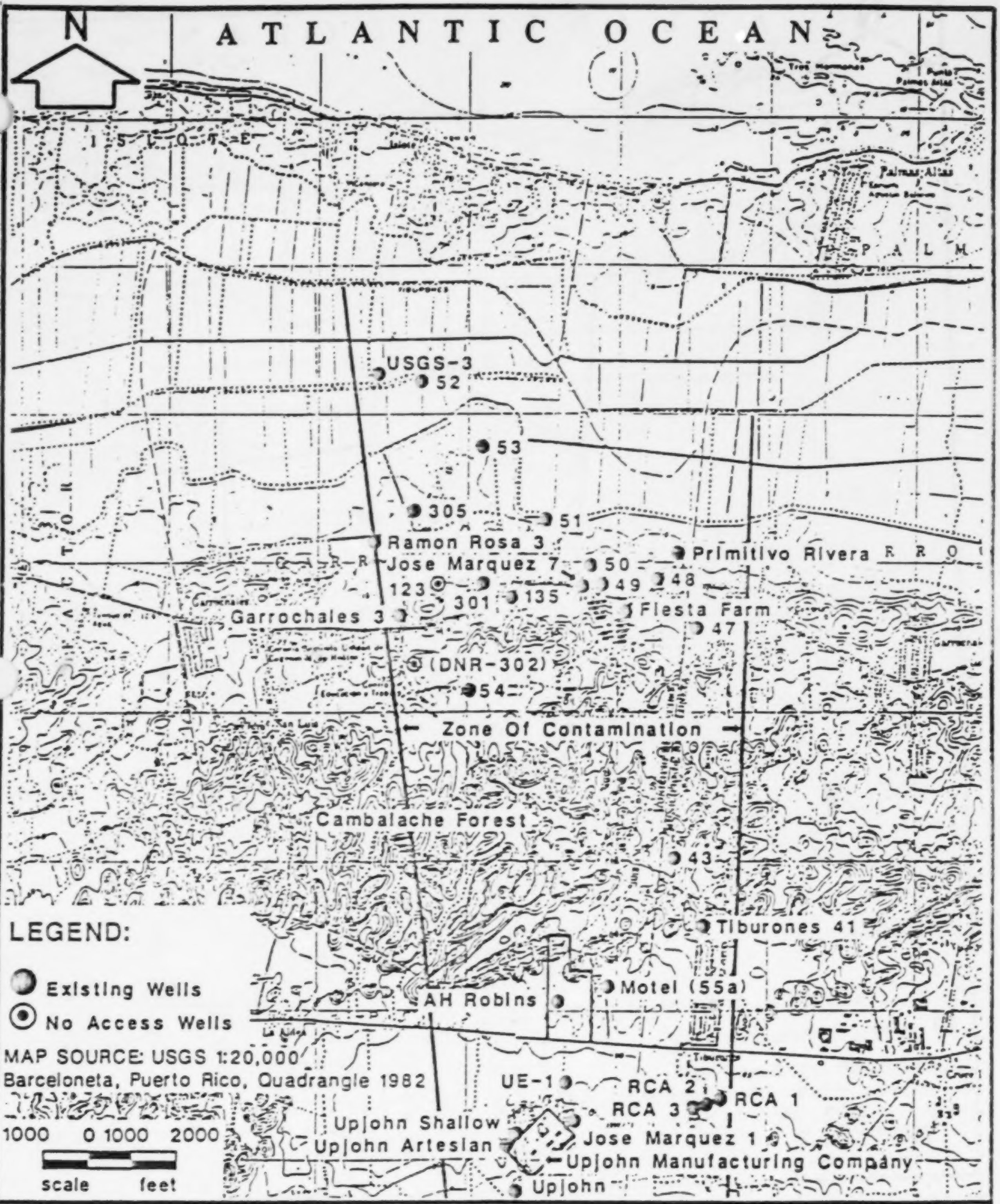
Figure 10

Zone Of Contamination

Upjohn Manufacturing Company
Barceloneta, Puerto Rico


N
ATLANTIC OCEAN
USGS-3
52
53
305
51
Ramon Rosa 3
Jose Marquez 7
50
Primitivo Rivera
123
301
135
49
48
Garrochales 3
Fiesta Farm
47
(DNR-302)
54
← Zone Of Contamination →
Cambalache Forest
43
Tiburones 41
LEGEND:
● Existing Wells
⊙ No Access Wells
AH Robins
Motel (55a)
UE-1
RCA 2
RCA 3
RCA 1
Upjohn Shallow
Upjohn Artesian
Jose Marquez 1
← Upjohn Manufacturing Company
Upjohn
1000 0 1000 2000
scale feet

MAP SOURCE: USGS 1:20,000
Barceloneta, Puerto Rico, Quadrangle 1982

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Figure 11

Location Of Wells Within Zone Of Contamination

Upjohn Manufacturing Company
Barceloneta, Puerto Rico

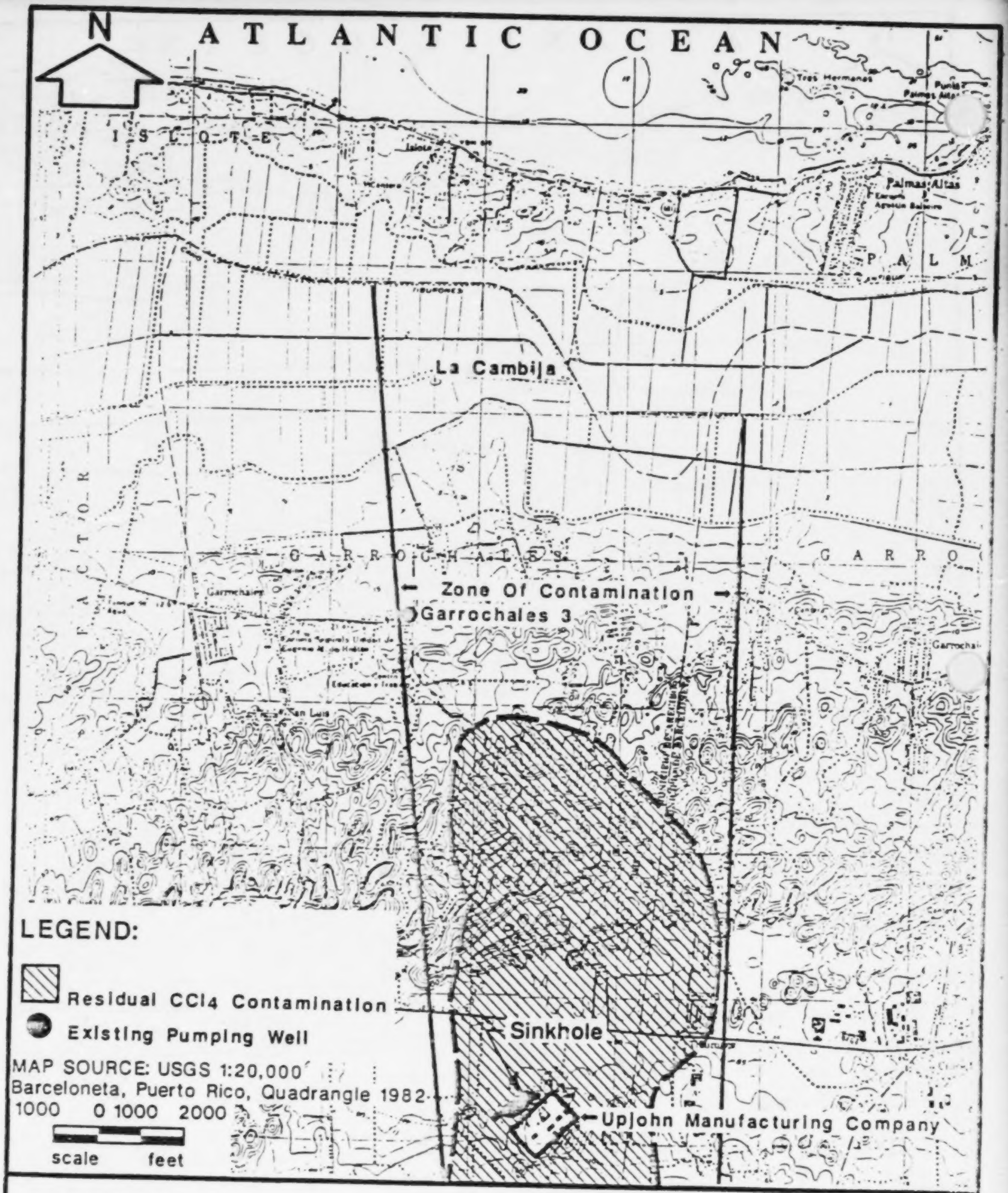
N
ATLANTIC OCEAN
ISLOTE
Tres Hermanos
Palmas Altas
PALM
La Cambija
FACTOR
GARROCHALES
GARRO
Garrochales
← Zone Of Contamination →
Garrochales 3
San Luis
Sinkhole
Upjohn Manufacturing Company
LEGEND:
▨ Residual CCl4 Contamination
● Existing Pumping Well
MAP SOURCE: USGS 1:20,000
Barceloneta, Puerto Rico, Quadrangle 1982
1000 0 1000 2000
scale feet

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Figure 12

Schematic Layout - Alternative 1

Upjohn Manufacturing Company
Barceloneta, Puerto Rico

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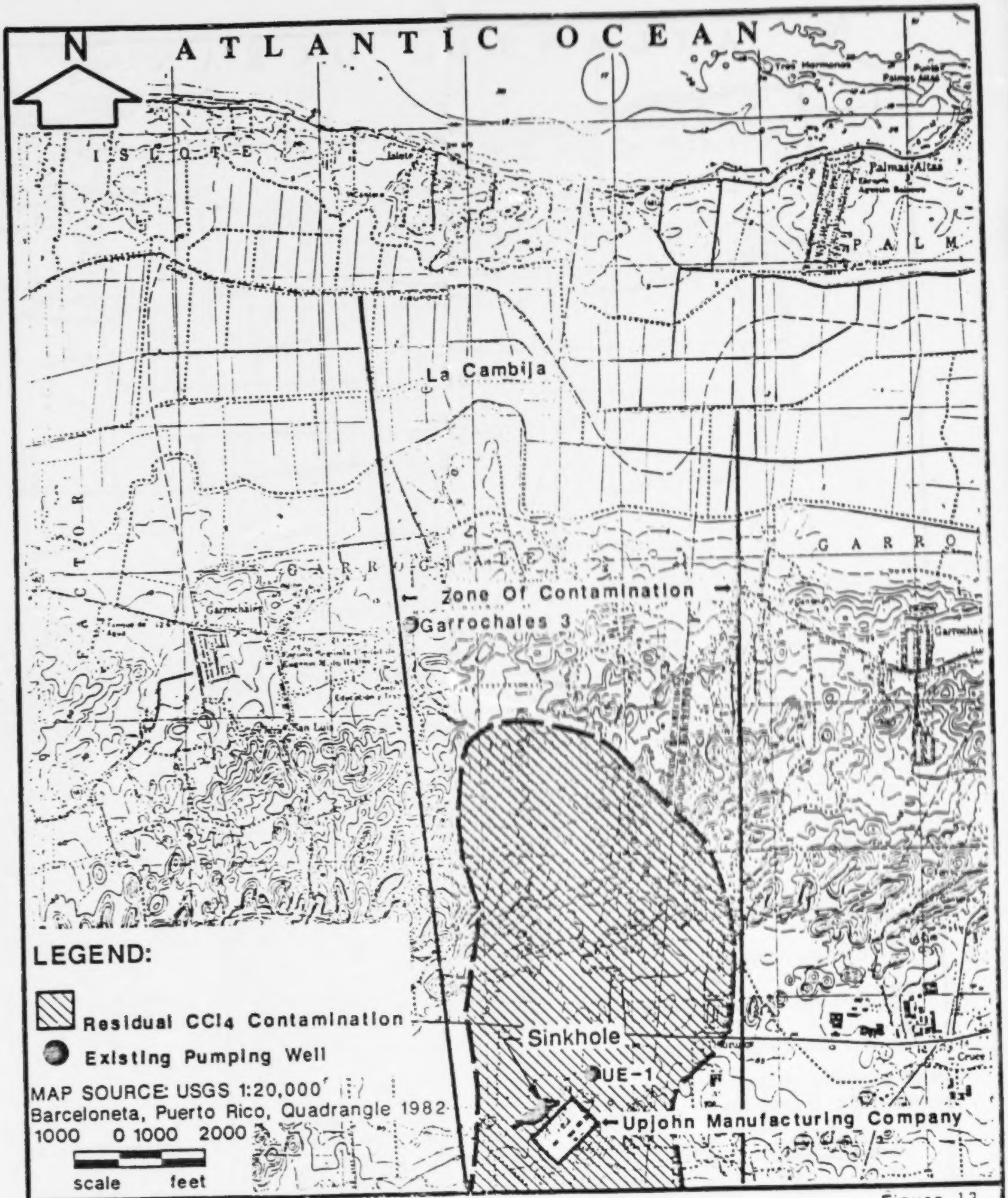
N
ATLANTIC OCEAN
ISLOTE
Islote
Palmas Altas
PALM
La Cambija
FACTOR
GARROCHALES
GARRO
Zone Of Contamination
Garrochales 3
Sinkhole
UE-1
Upjohn Manufacturing Company
LEGEND:
▨ Residual CCl_4 Contamination
● Existing Pumping Well
MAP SOURCE: USGS 1:20,000
Barceloneta, Puerto Rico, Quadrangle 1982
1000 0 1000 2000
scale feet

Figure 13

Schematic Layout - Alternative 2
Upjohn Manufacturing Company
Barceloneta, Puerto Rico

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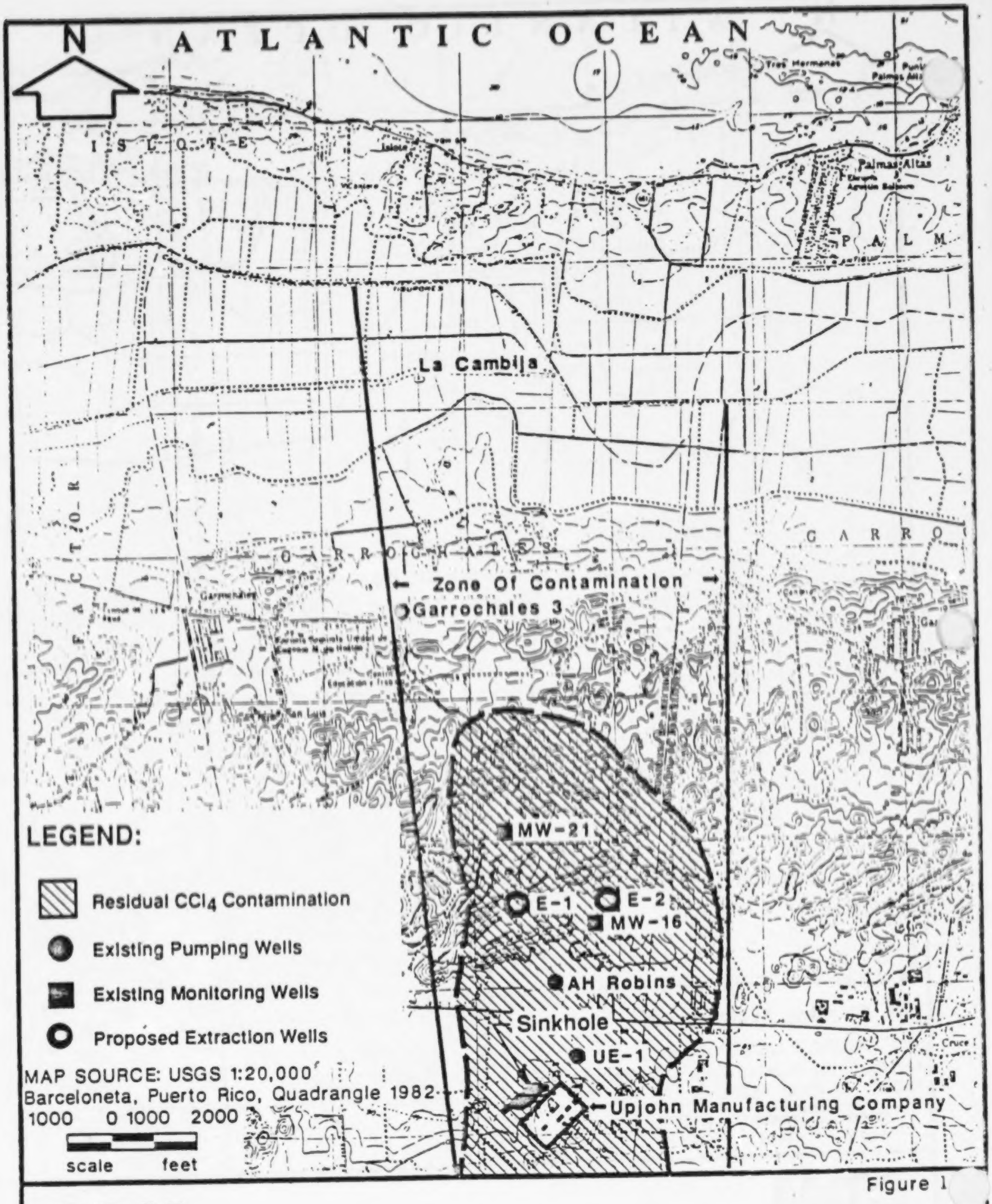
N
ATLANTIC OCEAN
Tres Hermanas
Palmas Altas
ISLOTE
Islote
PALM
La Cambija
FACTOR
GARROCHALES
GARRO
← Zone Of Contamination →
Garrochales 3
MW-21
E-1
E-2
MW-16
AH Robins
Sinkhole
UE-1
←Upjohn Manufacturing Company
LEGEND:
▨ Residual CCl_4 Contamination
● Existing Pumping Wells
■ Existing Monitoring Wells
○ Proposed Extraction Wells
MAP SOURCE: USGS 1:20,000
Barceloneta, Puerto Rico, Quadrangle 1982
1000 0 1000 2000
scale feet

Figure 1

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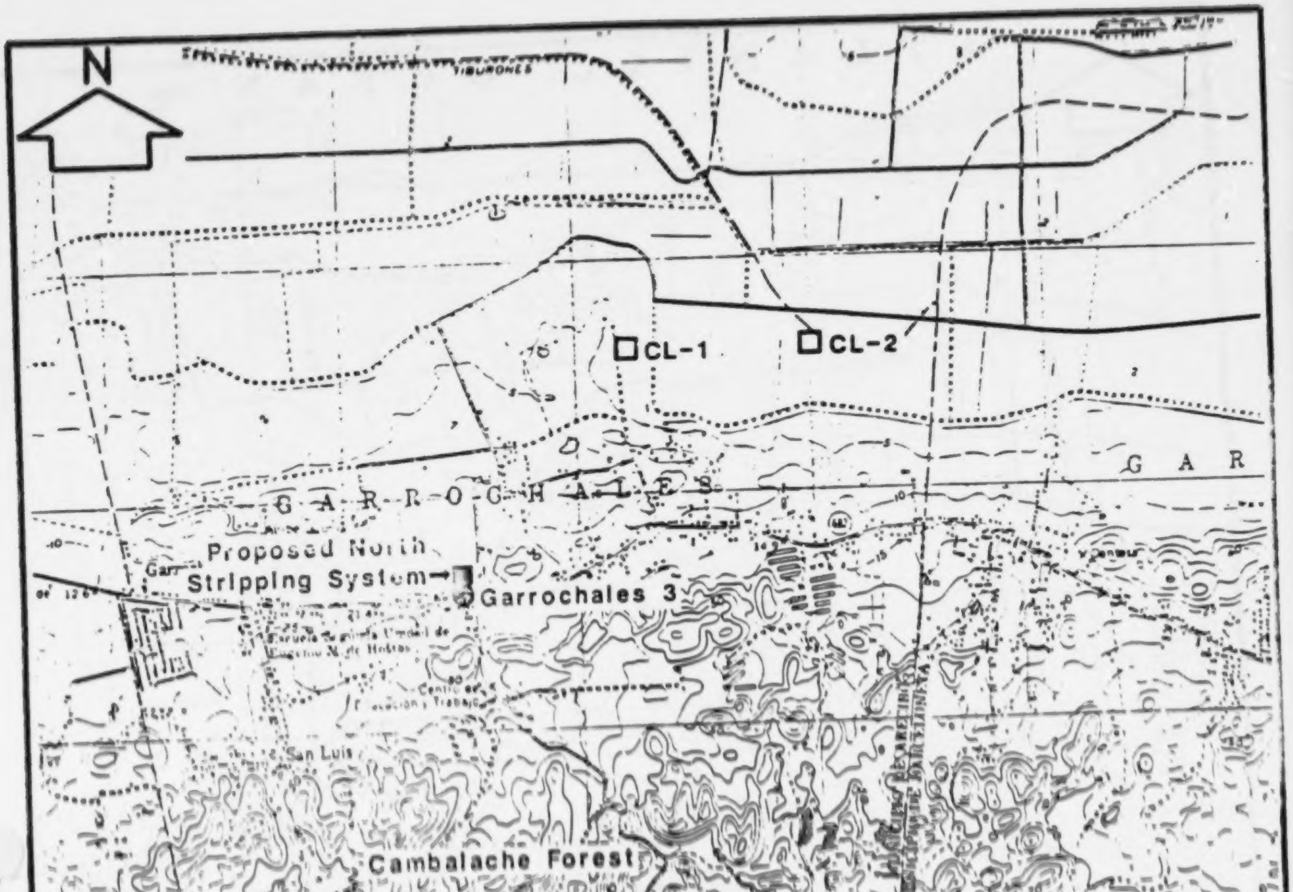
Schematic Layout - Alternative 3

Upjohn Manufacturing Company
Barceloneta, Puerto Rico


N
TIBURONES
CL-1
CL-2
G A R R O C H A L E S
G A R
Proposed North Stripping System
Garrochales 3
San Luis
Cambalache Forest
8"
8"
E-1
E-2
12"
AH Robins
14"
Sinkhole
UE-1
14"
Upjohn Manufacturing Company
South Air Stripping System
Tiburones
LEGEND:
▨ Residual CCl4 Contamination
● Existing Pumping Wells
○ Proposed Extraction Wells
☐ Proposed Chloride Monitoring Network
1000 0 1000
scale feet

MAP SOURCE: USGS 1:20,000
Barceloneta, Puerto Rico, Quadrangle 1982

Figure 15
Proposed Layout For The Ground Water Treatment Systems And Associated Piping–Alternative 3
Upjohn Manufacturing Company
Barceloneta, Puerto Rico

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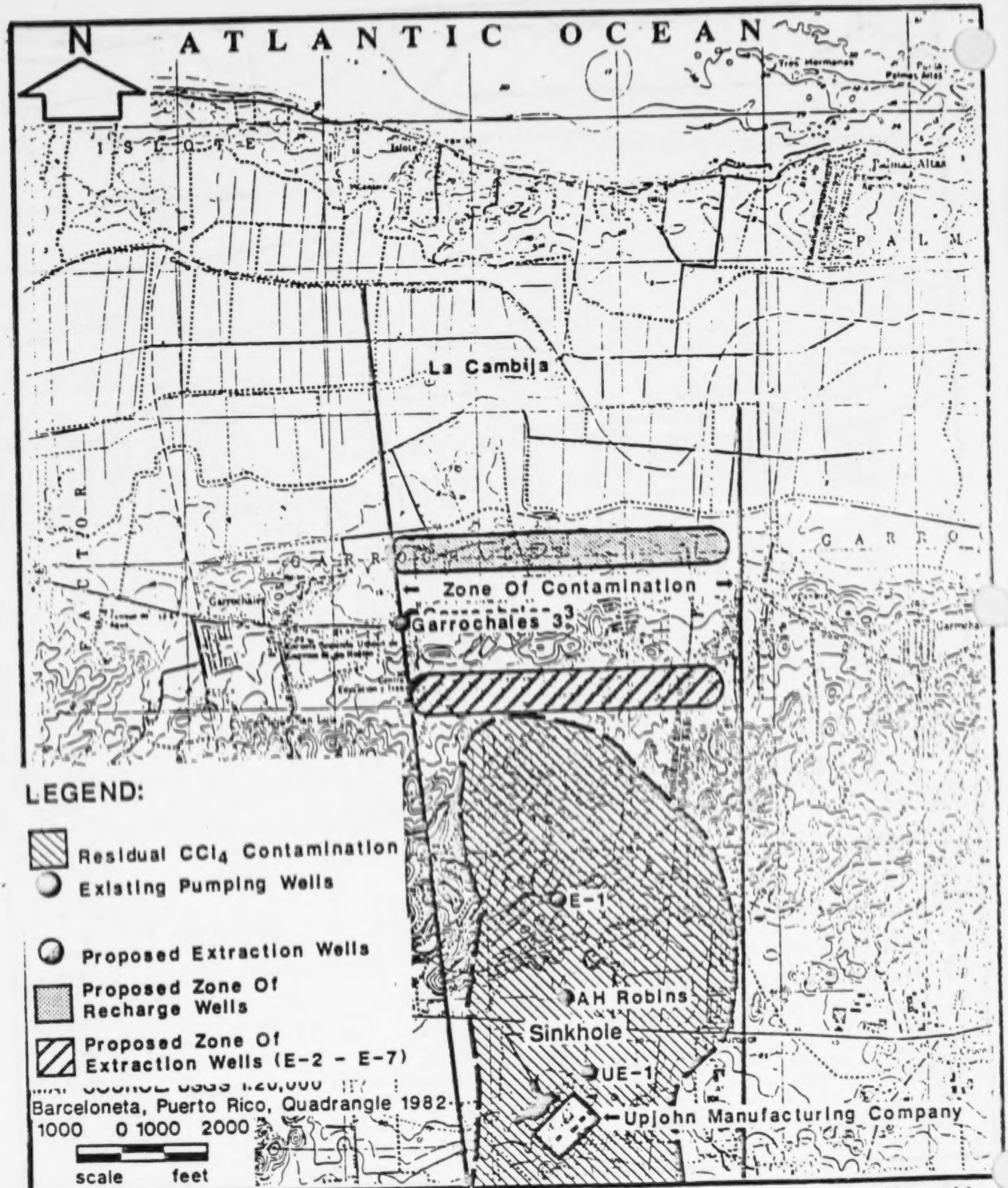
N
ATLANTIC OCEAN
Tres Hermanos
Punta Palmas Altas
ISLOTE
Islote
Palmas Altas
PALM
La Cambija
FACTOR
CARRO
GARRO
Zone Of Contamination
Garrochales 3
Garrochales
E-1
AH Robins
Sinkhole
UE-1
Upjohn Manufacturing Company
LEGEND:
▨ Residual CCl_4 Contamination
● Existing Pumping Wells
● Proposed Extraction Wells
▩ Proposed Zone Of Recharge Wells
▨ Proposed Zone Of Extraction Wells (E-2 - E-7)
1000 0 1000 2000
scale feet

MAP SOURCE USGS 1:20,000 Barceloneta, Puerto Rico, Quadrangle 1982

Figure 16

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Schematic Layout - Alternative 4

Upjohn Manufacturing Company
Barceloneta, Puerto Rico

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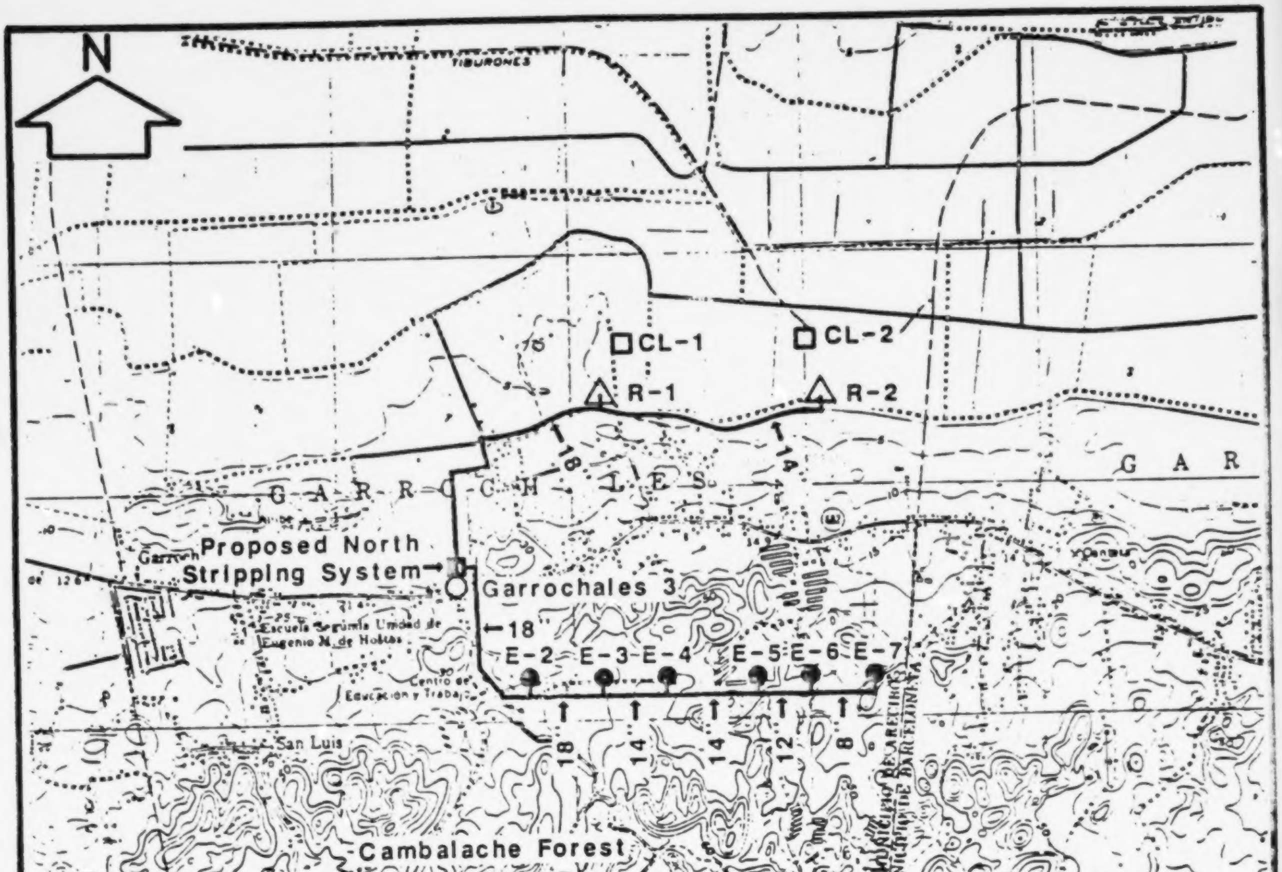
N
TIBURONES
CL-1
CL-2
R-1
R-2
G A R R O C H A L E S
G A R
Proposed North Stripping System
Garrochales 3
Escuela Segunda Unidad de Eugenio M. de Hostos
Centro de Educación y Trabajo
18
E-2
E-3
E-4
E-5
E-6
E-7
18
14
14
12
8
San Luis
Cambalache Forest
E-1
8
AH Robins
12"
Sinkhole
UE-1
14"
Tiburones
Upjohn Manufacturing Company
South Air Stripping System
LEGEND:
○ Existing Pumping Wells
● Proposed Extraction Wells
△ Proposed Recharge Wells
☐ Proposed Chloride Monitoring Networks
1000 0 1000
scale feet

MAP SOURCE: USGS 1:20,000
Barceloneta, Puerto Rico, Quadrangle 1982

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environmental engineers, scientists, planners & management consultants

Figure 17

Proposed Layout For The Ground Water Treatment Systems And Associated Piping-Alternative 4

Upjohn Manufacturing Company
Barceloneta, Puerto Rico

TABLE 1

GROUND WATER WELLS AND SPRING SAMPLED (1988)

Well No. Sampled	Specified Sampling Depth (below grade)	Concentration Level (ppb)
MW-1	(320')	55
MW-9	(310')	ND
MW-16	(320')	140
MW-18	(320')	160
MW-19	(400')	2.9
MW-20	(345')	ND
MW-21	(280')	59
MW-22	(290')	44
MW-23	(235')	170
MW-101	(235')	29
MW-102	(235')	ND
MW-103	(280')	2.4
Pollera #43		4.7
Job Corps #54		0.7
Garrochales 3, #54a		1.4
Vaqueria Martinez #47		ND
#48		ND
Morales #49		ND
#50		ND
#51		ND
La Cambija #52		13.0
Rosa Delgado #53		ND
PRASA Garrochales #135		ND
Julio Reyes #179		ND
Jossie Morales #301		ND
Vaqueria Sabana #305		6.4

ND - CCl_4 was not detected using a minimum detection limit of 1ppb.

(313/22)NY-SS

TABLE (CONT'D)

COMPOUNDS DETECTED IN THE GROUND WATER SAMPLES TAKEN IN THE VICINITY OF UMC, (JANUARY 1988) (1)

SAMPLE NO.	TB-01	TB-02	TB-03	TB-04	TB-05	TB-06	TB-07	TB-08	TB-09	TB-10	TB-11
ORGANICS:											
acetone	10.0 U	10.0 U	10.0 U	30.0	55.0	30.0 U	30.0 U	25.0 U	10.0 U	10.0 U	36.0
1,1,1-trichloroethane	5.0 U	5.0 U	3.0 J	3.0 J	500.0 E*	330.0 *	540.0 *	310.0 D*	170.0 *	6.0	21.0

Notes:(1) All values are in ppb unless noted otherwise
- U Indicates element was analyzed for but not detected. The number shown is the detection limit.
- J Indicates an estimated value; result is less than the specified detection limit.
- B Indicates the analyte was found in the blank. Indicates possible blank contamination.
- E Estimated value or not reported due to the presence of interference.
- * Exceeded State and/or Federal Guidelines or Criteria.
- TB Trip Blank

TABLE 1 (CONT'D)

COMPOUNDS DETECTED IN THE GROUND WATER SAMPLES TAKEN IN THE VICINITY OF UMC, (JANUARY 1988) (1)

SAMPLE NO.	FB-01	FB-02	FB-03	FB-04	FB-05	FB-06	FB-07	FB-08	FB-09
ORGANICS:									
acetone	990.0	10.0 U	82.0	37.0	10000.0	20.0 U	30.0 U	110.0	250.0
2-butanone	50.0 U	10.0 U	10.0 U	11.0	10.0 U	20.0 U	30.0 U	10.0 U	10.0 U
1,1,1-trichloroethane	25.0 U	5.0 U	2.0 J	4.0 J	370.0 E*	420.0 J*	400.0 *	8.0	6.0
benzene	25.0 U	5.0 U	5.0 U	5.0 U	2.0 J*	10.0 U	15.0 U	5.0 U	5.0 U
toluene	25.0 U	5.0 U	5.0 U	21.0	5.0 U	10.0 U	15.0 U	5.0 U	5.0 U
INORGANICS:									
aluminum	1380.0	9.6 J	19.0 J	8.0 U	8.0 U	21.0 U	32.0 J	45.0 J	21.0 U
antimony	22.0 U	22.0 U	22.0 U	22.0 U	22.0 U	15.0 U	15.0 U	15.0 U	37.0 J
barium	17.0 J	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
calcium	505.0 J	68.0 J	27.0 J	16.0 J	27.0 J	66.0 J	12.0 U	31.0 J	12.0 U
chromium	29.0	7.0 U	7.0 U	7.0 U	7.0 U	5.0 U	5.0 U	5.0 U	5.0 U
cobalt	5.1 J	5.0 U	6.1 J	5.0 U	5.0 U	4.0 U	4.0 U	4.0 U	4.0 U
copper	5.0 J	5.0 J	5.0 J	8.3 J	5.0 J	4.0 U	4.0 U	4.0 U	4.0 U
iron	1160.0 *	13.0 U	14.0 J	13.0 U	13.0 U	8.0 U	8.0 U	9.6 J	8.0 J
magnesium	4290.0 J	21.0 J	58.0 J	21.0 J	58.0 J	11.0 J	4.6 J	26.0 J	6.3 J
manganese	5.4 J	2.0 U	2.0 U	4.2 J	2.0 U	4.1 J	2.0 U	2.7 J	2.0 U
mercury	0.2 U	0.2 U	0.2 U	0.34	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
sodium	38.0 J	33.0 J	26.0 J	67.0 J	26.0 J	55.0 J	245000.0	38.0 J	55.0 J
thallium	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 J	10.0 J	10.0 J	10.0 J
zinc	8.1 J	12.0 J	6.2 J	6.1 J	8.3 J	2.0 U	2.0 U	2.9 J	2.0 U

Notes:(1) All values are in ppb unless noted otherwise
- U Indicates element was analyzed for but not detected. The number shown is the detection limit.
- J Indicates an estimated value; result is less than the specified detection limit.
- B Indicates the analyte was found in the blank. Indicates possible blank contamination.
- * Exceeded State and\or Federal Guidelines or Criteria
- E Estimated value or not reported due to the presence of interference.

TABLE 1 (CONT'D)

COMPOUNDS DETECTED IN THE GROUND WATER SAMPLES TAKEN IN THE VICINITY OF UMC, (JANUARY 1988) (1)

WELL NO.	DW-48	DW-49	AW-50	AW-51	SW-52	IW-53	DW-135	LS-179	AW-301	LS-305
ORGANICS:										
2-butanone	9.0 J	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U
carbon tetrachloride	0.2 U	0.2 U	0.2 U	0.2 U	13.0 *	0.2 U	0.2 U	5.0 U	0.2 U	6.4
toluene	24.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
INORGANICS:										
aluminum	8.0 U	32.0 J	202.0	21.0 U	21.0 U	21.0 J	21.0 U	578.0	307.0	8.0 U
arsenic	10.0 U	10.0 U	35.0	205.0 *	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U
barium	12.0 J	62.0 J	56.0 J	26.0 J	15.0 J	19.0 J	20.0 J	78.0 J	74.0 J	21.0 J
cadmium	4.0 U	5.0 U	4.0 U	5.0 U	5.0 U	4.0 U	5.0 U	4.0 U	7.4 *	4.0 U
calcium	112000.0	83400.0	115000.0	75900.0	142000.0	111000.0	88900.0	142000.0	61500.0	93600.0
chromium	7.4 J	5.0 U	12.0	5.5 J	6.2 J	7.0 U	5.0 U	7.0 U	14.0	7.0 U
cobalt	5.0 U	4.0 U	5.0 U	4.0 U	4.0 U	5.0 U	4.0 U	5.0 U	13.0 J	5.0 U
copper	5.0 J	4.0 U	14.0 J	4.0 U	80.0 U	5.0 J	4.0 U	26.0	11.0 J	5.0 J
iron	60.0 J	99.0 J	1450.0 *	198.0 J	14.0 J	229.0	18.0 J	2260.0 *	3880.0 *	14.0 J
lead	5.0 U	5.0 U	5.0 U	6.8	6.9 F	5.0 U	5.0 U	5.0 U	28.0 J*	5.0 U
magnesium	23000.0	15400.0	15700.0	7120.0	134000.0	15700.0	6290.0	18300.0	27100.0	16300.0
manganese	8.3 F	6.3 F	117.0 *	2.5 J	7.3 F	10.0 J	5.9 J	19.0 U	623.0 *	39.0
mercury	1.2	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2	0.2 U	0.29
potassium	8050.0	2710.0 J	2560.0 J	1220.0 J	43400.0	5130.0	1330.0 J	2460.0 J	15600.0	5170.0
selenium	5.0 U	5.0 U	5.0 U	37.0 *	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
sodium	185000.0	53000.0	74300.0	35900.0	2580000.0	143000.0	29400.0	89400.0	88000.0	74700.0
thallium	100.0 U	10.0 J	100.0 U	10.0 J	10.0 J	100.0 U	10.0 J	50.0 U	100.0 U	100.0 U
vanadium	11.0 J	3.0 U	11.0 J	3.6 J	3.0 U	8.3 J	3.0 J	8.3 J	4.0 U	4.0 U
zinc	25.0	111.0	75.0	440.0	12.0 J	10.0 J	196.0	9.5 F	4200.0	53.0

Notes: (1) All values are in ppb unless noted otherwise.
U Indicates element was analyzed for but not detected. The number shown is the detection limit.
J Indicates an estimated value; result is less than the specifed detection limit.
B Indicates the analyte was found in the blank. Indicates possible blank contamination.
F Failed quality control review per EPA
* Exceeds State or Federal Guidelines and/or Criteria.
DW Domestic Well
AW Abandoned Well
SW Surface Water
IW Irrigation Well
LS Livestock Well

TABLE 1 (CONT'D)

COMPOUNDS DETECTED IN THE GROUND WATER SAMPLES TAKEN IN THE VICINITY OF UMC (JANUARY 1988) (1)

WELL NO.	MW-23	MW-101	MW-102	MW-102 DUP.	MW-103	DW-43	IW-54	PW-54A	DW-47
ORGANICS:									
acetone	26.0	37.0 F	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U
chloroform	10.0	4.0 J	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
carbon tetrachloride	170.0 *	29.0 *	0.2 U	0.2 U	2.4 *	4.7 *	0.7 *	1.4 *	0.2 U
INORGANICS:									
aluminum	115.0 J	85.0 J	25.0 J	132.0 J	243.0	8.0 U	445.0 F	8.7 F	21.0 U
antimony	22.0 U	22.0 U	15.0 U	15.0 U	22.0 U	116.0	22.0 U	22.0 U	22.0 J
barium	12.0 J	19.0 J	14.0 J	15.0 J	20.0 J	8.3 J	11.0 F	11.0 F	9.3 J
cadmium	4.0 U	4.0 U	5.0 U	5.0 U	4.0 U	4.1 J	4.0 U	4.0 U	5.0 U
calcium	111000.0	108000.0	104000.0	104000.0	78500.0	109000.0	96400.0	103000.0	117000.0
chromium	7.0 U	2980.0 *	1240.0 *	831.0 *	350.0 *	7.0 U	28.0	7.0 U	9.0 J
cobalt	5.0 U	19.0 J	26.0 J	14.0 J	9.2 J	5.0 U	5.1 J	5.0 U	4.0 U
copper	5.0 J	56.0 J	36.0	22.0 J	17.0 J	5.0 J	68.0 J	5.0 J	4.8 J
iron	182.0	25700.0 *	15600.0 F	7790.0 F	7440.0 *	32.0 J	6510.0 *	13.0 U	242.0
lead	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	85.0 *	5.0 U	34.0 J*
magnesium	33200.0	10600.0	11800.0	11800.0	2990.0 J	18800.0	11600.0 F	11900.0 F	8490.0
manganese	7.5 J	70.0 *	156.0 *	122.0 *	54.0 *	2.0 U	236.0 *	2.0 U	19.0 F
nickel	16.0 U	814.0	1350.0	888.0	472.0	16.0 U	16.0 U	16.0 U	9.0 U
potassium	9100.0	3120.0 J	4460.0 J	4640.0 J	1700.0 U	7710.0	3920.0 J	3960.0 J	1820.0 J
sodium	326000.0	87700.0	91400.0	91800.0	8990.0	176000.0	68700.0	80300.0	1150000.0
vanadium	4.7 J	30.0 J	5.8 J	3.0 U	10.0 J	9.0 J	20.0 J	7.9 J	3.0 U
zinc	12.0 J	32.0	9.4 J	16.0 J	30.0	33.0	872.0	8.3 J	74.0
						FB-01 =====	FB-02 =====	FB-03 =====	
DISSOLVED METALS:									
aluminum		8.0 U	8.0 U	8.0 U	8.0 U	59.0 J	8.0 U	21.0 J	
barium		2.0 U	2.0 U	2.0 U	10.0 J	2.0 U	2.0 U	2.6 J	
calcium		99000.0	86600.0	88300.0	65300.0	82.0 J	70.0 J	32.0 J	
chromium		7.0 U	9.9 J	7.0 U	7.0 U	7.0 U	7.0 U	7.0 U	
cobalt		5.0 U	5.0 U	5.0 U	5.0 U	5.0 J	5.0 U	5.0 U	
copper		5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	
iron		45.0 J	74.0 J	34.0 J	97.0 J	21.0 J	13.0 U	24.0 J	
magnesium		9330.0	2850.0 J	2960.0 J	2920.0 J	71.0 J	20.0 J	62.0 J	
manganese		3.5 J	25.0	16.0	20.0	2.0 U	2.0 U	2.0 U	
nickel		68.0	421.0	379.0	224.0	16.0 U	16.0 U	16.0 U	
potassium		3240.0 J	1700.0 U	1700.0 U	1700.0 U	1700.0 U	1700.0 U	1700.0 U	
sodium		75000.0	17300.0	18200.0	8240.0	198.0 J	88.0 J	54.0 J	
zinc		6.7 F	6.0 U	6.0 U	7.8 F	6.7 J	6.7 J	20.0	

Notes:(1) All values are in ppb unless noted otherwise
U Indicates element was analyzed for but not detected. The number shown is the detection limit.
J Indicates an estimated value; result is less than the specified detection limit.
B Indicates the analyte was found in the blank. Indicates possible blank contamination.
* Exceeded State and/or Federal Guidelines or Criteria.
MW Monitoring Well
DW Domestic Well
IW Irrigation Well
PW Public Water Supply
FB Field Blank
F Failed quality control review per EPA

TABLE I (CONT'D)

COMPOUNDS DETECTED IN THE GROUND WATER SAMPLES TAKEN IN THE VICINITY OF UMC (JANUARY 1988) (1)

WELL NO.	MW-01	MW-09	MW-16	MW-16 DUP.	MW-18	MW-19	MW-20	MW-21	MW-22
ORGANICS:									
acetone	61.0 F	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	41.0 F	10.0 U
chloroform	2.0 J	5.0 U	11.0	12.0	21.0	5.0 U	5.0 U	2.0 J	4.0 J
carbon tetrachloride	55.0 *	0.2 U	120.0 *	140.0 *	160.0 *	2.9 *	0.2 U	59.0 *	44.0 *
INORGANICS:									
aluminum	9.4 F	142.0 J	93.0 J	52.0 J	21.0 U	22.0 F	127.0 J	162.0 J	77.0 J
barium	8.3 F	5.8 J	2.0 U	2.0 U	7.6 J	7.8 J	3.7 J	19.0 J	9.6 J
calcium	88200.0	115000.0	87600.0	82700.0	93200.0	89200.0	88500.0	126000.0	107000.0
chromium	8.2 J	17.0	7.0 U	23.0	5.0 U	9.1 J	9.9 J	7.0 U	15.0
copper	5.0 J	4.0 U	15.0 J	19.0 J	4.0 U	4.0 U	5.1 J	5.0 J	4.0 U
iron	73.0 F	415.0 J*	324.0 F	466.0 *	15.0 J	47.0 J	227.0 J	287.0	288.0
magnesium	3540.0 F	2030.0 J	9110.0	8660.0	3310.0 J	4030.0 J	2710.0 J	57400.0	20400.0
manganese	2.5 F	12.0 J	4.6 J	9.0 J	2.7 J	3.8 J	17.0	2.0 U	8.2 J
potassium	1700.0 U	489.0 U	1700.0 U	1700.0 U	489.0 U	489.0 U	489.0 U	14500.0	3720.0 J
sodium	7280.0	4840.0 J	59800.0	57100.0	18800.0	22600.0	10400.0	570000.0	577000.0
vanadium	4.0 U	5.2 J	5.5 J	4.0 U	3.0 U	3.0 U	3.6 J	6.8 J	3.0 U
zinc	12.0 J	10.0 J	18.0 J	22.0	6.3 J	5.8 J	18.0 J	9.3 J	10.0 J

Notes:(1) All values are in ppb unless noted otherwise
U Indicates element was analyzed for but not detected. The number shown is the detection limit.
J Indicates an estimated value; result is less than the specified detection limit.
B Indicates the analyte was found in the blank. Indicates possible blank contamination.
* Exceeded State and/or Federal Guideline or Criteria
MW Monitoring Well
F Failed quality control review per EPA

TABLE 2

SUMMARY OF CARCINOGENIC RISKS FROM CARBON TETRACHLORIDE

EXPOSED POPULATION	EXPOSURE ROUTE	EXPOSURE MEDIUM	EXPOSURE POINT	CANCER RISK
Adult resident	Ingestion	Groundwater	AH Robins	2.3 x 10-4
			Cambalache Forest Area	8.8 x 10-5
			Garrochales Area	6.9 x 10-5
			Cano Tiburones	5.8 x 10-5
	Inhalation	Ambient Air	Nearest Residence	3.9 x 10-7
Plant Workers	Inhalation	Ambient Air	Air-Stripping Unit	1.6 x 10-5

TABLE 4

SUMMARY OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE STATE AND FEDERAL REGULATIONS AND GUIDELINES AND CRITERIA TO BE CONSIDERED FOR POTABLE DRINKING WATER *

COMPOUNDS	PRIM.	SEC.	MCLG	MCL	PRDOH RULE #50	PRDOH NMCR
ORGANICS:						
acetone						
benzene			0.0	5.0		5.0
2-butanone						
carbon tetrachloride			0.0	5.0		50.0
chloroform						50.0
toluene			2000.0**			50.0
1,1,1-trichloroethane			200.0	200.0		100.0
INORGANICS:						
aluminum						
antimony						
arsenic	50.0		50.0		50.0	
barium	1000.0		1500.0		1000.0	
beryllium						
cadmium	10.0		5.0		10.0	
calcium						
chromium			120.0	50.0		
cobalt						
copper		1000.0	1300.0			
iron		300.0				
lead	50.0		20.0		50.0	
magnesium						
manganese		50.0				
mercury	2.0		3.0		2.0	
nickel						
potassium						
selenium	10.0		45.0		10.0	
silver	50.0				50.0	
sodium						
thallium						
vanadium						
zinc		5000.0				

PRDOH - Puerto Rico Department of Health
NMCR - Regulations for maximum level of contamination.
* all units in parts per billion (ppb).
** Proposed Recommended Maximum Contaminent Level, Fed. Reg. 11/13/85

ATTACHMENT 1

COMMONWEALTH OF PUERTO RICO / OFFICE OF THE GOVERNOR
Environmental
Quality Board

September 23, 1988

Mr. Carlos E. O'Neill
Acting Director
Caribbean Field Office, EPA
1413 Fernandez Juncos Avenue
Santurce, Puerto Rico 00909

RE: UPJOHN MANUFACTURING,CO.
BARCELONETA, PUERTO RICO

Dear Mr. O'Neill:

The Environmental Quality Board received the Proposed Plan for Remedial Action for Upjohn Manufacturing Co., Barceloneta which included a modified Alternative 3 as the recommended alternative by the Environmental Protection Agency (E.P.A).

This alternative is a modification of Alternative 3, Moderate Control of the Contaminant, as presented in the Feasibility Study for this facility. It involves continued pumpage with treatment of well UE-1, A.H. Robins and Garrochales 3 with the installation and operation of two new extraction wells. Under this alternative Garrochales 3 would continue to be used as a potable water source following well-head treatment; groundwater from UE-1 and A.H. Robins would be treated and discharged to an existing sinkhole located northwest of the Upjohn facility; the two extraction wells would also be treated and discharged to that sinkhole. Long-term ground water monitoring would be implemented. If the two new installed wells prove to be effective in controlling and removing the contaminants as well to protect the aquifer from saline instruction, E.P.A. maintain the option of install additional extraction wells.

After the corresponding evaluation, this Board concurred with E.P.A. that this is the most environmental sound and safe alternative.

Nevertheless, we want to emphasize the importance of long-term groundwater monitoring at Garrochales 3 to assure the quality of the drinking water that would be serve to the community.

Should you have any question, please contact me at (809) 722-1757.

Sincerely yours,

Heriberto Torres, Ph. D
Acting President

cc: Mr. Pedro A. Gelabert
Mr. José Font
Mr. Santos Rohena
Mr. Juan Merced Mateo

JP-bss

RESPONSIVENESS SUMMARY
UPJOHN MANUFACTURING COMPANY SUPERFUND SITE
BARCELONETA, PUERTO RICO

A. OVERVIEW

On July 12, 1988, the U.S. Environmental Protection Agency (EPA) Region II Office began a 30-day comment period on the 1988 Feasibility Study (FS) and the proposed alternative for remediation of the Upjohn Manufacturing Company (UMC) Superfund site in Barceloneta, Puerto Rico. Prior to the public comment period, EPA had selected a preferred alternative for the UMC site. The preferred alternative outlined in the proposed remedial action plan (PRAP) consisted of extracting contaminated groundwater by pumping two existing wells (UE-1 and A.H. Robins), installing two new groundwater extraction wells for the same purpose, and continuing to use the Garrochales #3 public supply well as a drinking water source after installing an air stripper to remove any contamination. Additional extraction wells could be installed if the two initially installed wells are effective at removing contaminants. Extracted water from the UE-1, A.H. Robins, and new extraction wells would be treated by air stripping and recharged back into the aquifer. The preferred alternative also called for long-term groundwater monitoring.

Based on comments received during the public comment period, local residents and officials support the active control of contaminants through groundwater extraction. Citizen concern centered mostly on the effect of the contamination on the nearby river, Cano Tiburones, and the time frame for remediation. UMC felt that EPA should select the alternative proposed by the company's FS, specifically, to continue pumping only the UE-1 well to extract contaminated groundwater from the aquifer and to replace contaminated water supplies wherever necessary.

These sections follow:

- Community Involvement in the Selection Process
- Summary of Major Comments Received During the Public Comment Period and Agency Responses
- Attachment 1: Proposed Remedial Action Plan
- Attachment 2: Proposed Remedial Action Plan (Spanish Version).
- Attachments 3-7: Written Comments

B. COMMUNITY INVOLVEMENT IN THE SELECTION PROCESS

On the evening of July 21, 1988, EPA held a public meeting at the Mayor's Office in Barceloneta, Puerto Rico to present the findings of the FS and the PRAP for the UMC site. Because Spanish is the primary language of the majority of the local residents, the meeting was held in Spanish to foster public involvement. A member of the EPA Caribbean Field Office staff summarized and translated questions to and responses from non-Spanish speaking EPA representatives at the meeting. In addition to being available at the information repositories, copies of the PRAP, in English and Spanish, were handed out at the meeting. The two-and-a-half hour public meeting was attended by approximately 35 persons.

Earlier in the day, EPA held a briefing for Commonwealth and local officials which was attended by approximately 20 people. Questions raised during both the public meeting and the briefing, and written questions and comments received by EPA during the public comment period are addressed in Section C of this responsiveness summary.

C. SUMMARY OF MAJOR COMMENTS RECEIVED DURING THE PUBLIC COMMENT PERIOD AND EPA'S RESPONSE TO COMMENTS

Both verbal and written comments received during the UMC comment period on the draft FS and PRAP are summarized below. The comment period was held from July 12 to August 10, 1988. The comments are categorized by topic, and similar questions have been consolidated and summarized.

Remedial Alternative Preferences

1. The Puerto Rico Department of Natural Resources (PRDNR) is in favor of EPA's preferred alternative with the following exceptions:

    - The Garrochales #3 well should only be used for aquifer remediation, with reinjection of treated water into the aquifer. This well should not be used as a source of potable water.

    - A new potable water source should be supplied from the artesian aquifer by either installing a new well or by using the Tiburones well.

EPA RESPONSE: During the remedial design phase of the implementation of the selected alternative EPA will evaluate the possibility of replacing treated water from the Garrochales #3 well with an alternate water supply from the artesian aquifer. Since the pumpage of the Garrochales #3 well is not an integral part of the remediation scheme called for under the selected alternative, this well may be taken out of service should an artesian well be installed. Issues such as the safe yield of the Cibao/Lares formation, its water quality, whether connections to a public distribution system exist, and optimum placement of an artesian well would take time to address, as would the actual installation of the well. Because of the time required to implement a new water supply from the artesian aquifer, EPA believes the Garrochales #3 well water should be air stripped, as a precautionary measure, until the new system is provided for, if ever, or until carbon tetrachloride (CCl_4) levels in the aquifer meet the Maximum Contaminent Level (MCL) of 5 ppb for CCl_4.

The Mayor of Barceloneta was strongly opposed to providing water to the Garrochales community from the Tiburones artesian well. Therefore, this option will not be further evaluated.

2. The United States Geological Survey (USGS) prefers Alternative 3 because it will achieve greater aquifer restoration without seriously threatening the aquifer from salt water encroachment, and strongly supports a long-term groundwater monitoring program and recharge of treated groundwater into the aquifer. USGS rejects Alternative 4 because it significantly increases the potential for salt water encroachment in the Garrochales area.

EPA RESPONSE: EPA's selected alternative is a modification of Alternative 3, which will include a long-term groundwater monitoring program and recharge of treated groundwater into the aquifer. EPA recognizes the importance of protecting the water table aquifer from salt-water intrusion, and will request the full involvement of USGS during the review process for this project.

3. UMC recommends the continued operation of the UE-1 groundwater extraction well with treatment by air stripping and recharge through the existing sinkhole, continued groundwater monitoring, and the provision of alternative sources of potable water if required. UMC believes current groundwater conditions at the Garrochales #3 well do not justify treatment, and, if they did, that replacing the Garrochales #3 well with an artesian well is feasible and could be implemented quickly and at a lower cost.

EPA RESPONSE: EPA rejects UMC's recommendation to operate only the existing groundwater extraction well, UE-1, and not to install additional extraction wells. The UE-1 well is only capable of removing contaminants and controlling migration within its cone of depression. Any contaminants present in the aquifer downgradient of AH Robins will not be controlled by the UE-1 well and will continue to migrate to Cano Tiburones. UMC's recommended action would rely very heavily on natural aquifer flushing and dilution to restore the aquifer and would render the aquifer unusable for a longer period of time than would EPA's selected alternative.

The Garrochales #3 well lies in the pathway of contaminant migration. Historic as well as recent sampling of this well indicates the presence of CCl_4 at levels less than the MCL of 5 ppb. However, the possibility exists that CCl_4 contaminant levels in this well could rise in the future. For this reason, EPA believes treatment of the Garrochales #3 well, as a precautionary measure, is justified.

EPA will evaluate replacement of the Garrochales #3 well with an artesian well during the design phase of the selected alternative. (See response to comment #1 above.)

Technical Questions/Concerns

4. Several people asked how long each alternative would take to remove all of the contaminants from the aquifer.

EPA RESPONSE: Due to the complex nature of the hydrogeology in the area and the possibility that residual CCl_4 contamination may exist in the unsaturated zone and may represent a persistent source of contaminants to the groundwater, it is not possible to determine the exact or approximate time frames for total aquifer remediation, if at all feasible, for any of the four alternatives. It is believed that active pumping of the aquifer as proposed under Alternative 2 and to a much greater extent under Alternatives 3 and 4 will remove contaminants more quickly from the aquifer than the No Action Alternative. How much faster cannot be determined.

5. A member of the community asked why EPA proposed two and not three or seven new groundwater extraction wells.

EPA RESPONSE: Alternative 3 includes the installation of two extraction wells. Alternative 4 includes the installation of seven extraction wells. Because of the uncertainty of the effectiveness of groundwater extraction wells at removing contaminants in this type of geological setting, EPA did not feel it would be prudent to select Alternative 4. In addition, Alternative 4 is very costly in comparison to the other alternatives. EPA cannot say that Alternative 4 is a cost-effective alternative given its cost and the questions regarding the effectiveness of the extraction well system called for under Alternative 4. Instead, EPA is selecting a modification of Alternative 3, which includes the installation of two extraction wells. If these two extraction wells are shown to be effective at removing contaminants from the aquifer, additional extraction wells will be installed for added contaminant removal.

6. UMC asked how EPA would determine whether the groundwater extraction wells proposed under the preferred alternative were effective and what would be done if the wells were ineffective.

   EPA RESPONSE: The effectiveness of the proposed extraction wells in removing contaminants and controlling migration of contaminants in the aquifer will be assessed by the improvement in the quality of the water downgradient of the contamination and the water pumped from the extraction wells. If any extraction well is determined to be ineffective at removing contaminants from the groundwater, an evaluation will be made at that time as to whether the well will remain in service.

7. UMC asked how salt water intrusion and vertical upconing would be addressed under the preferred alternative.

   EPA RESPONSE: The selected alternative includes a monitoring well network which will be installed to monitor the chloride content of the groundwater. These monitoring wells will identify salt water intrusion. In addition, the recharging of treated groundwater as called for under the selected alternative will significantly reduce the potential for salt water intrusion. Vertical upconing of salt water will be addressed by monitoring the extraction wells, including Garrochales #3, for chloride content.

   The information presented in the FS is a preliminary design and will be fully developed during the design phase. It is EPA's intention that extensive refinement of the monitoring network design will occur during the design of the remedial action and that the Commonwealth agencies will participate extensively in the conceptual design and design review processes of the project.

   Such issues as frequency of sampling and horizontal/vertical placement of the wells are design choices and will be appropriately addressed during the design phase. It is suggested that groundwater monitoring wells in the area of concern be sampled and analyzed for conventional water quality parameters.

8. UMC is unsure as to what the preferred alternative includes in terms of the air-stripping systems and pretreatment for these systems. UMC has recently installed a pretreatment system for its air stripper. UMC believes its air stripper has been operating reliably and that there is no justification to upgrade the system.

   EPA RESPONSE: The selected alternative includes the upgrade of the existing open basin aeration system to a packed column aeration system, as well as the installation of a new packed column aeration system for the Garrochales #3 well. These systems would be designed to reduce CCl_4 contaminants in the effluent to levels no greater than the MCL of 5 ppb. Pretreatment measures will also be taken with respect to each aeration unit to reduce the formation of scale. Packed column aeration has been selected over open basin aeration because of the greater control, reliability and removal efficiency afforded by the system.

   EPA was unaware of UMC's recent installation of a pretreatment system to its currently operating aeration system. During design, EPA will review UMC's plans and specifications as well as operational history of its pretreatment and aeration systems to reevaluate the need for modifications to these systems.

9. UMC believes EPA's FS disregards possible contamination from other sources, such as the Arecibo Landfill and the Cambalache State Forest, both of which are included on EPA's CERCLIS list. UMC states that if it is true that alternate sources are contributing to the CCl_4 contamination and that these sources cannot be remediated, then it is likely that EPA's preferred alternative will not meet the MCL of 5 ppb for CCl_4 throughout the aquifer. UMC asserts that if these sources can be remediated, then such remediation may be less costly than and as effective as the EPA preferred alternative in restoring the aquifer. Investigation of alternate CCl_4 sources should be conducted and remediation of these sources considered, UMC says, before the EPA preferred alternative is adopted and implemented.

   EPA RESPONSE: The Arecibo Landfill site and the Cambalache State Forest site are both included on EPA's CERCLIS list, which lists non-operational potential hazardous waste sites in the country. Preliminary assessments and site inspections were performed for both sites. Presently there are insufficient data and evidence to support the conclusion that these sites are contributing to the CCl_4 contamination in the groundwater at the UMC site.

   Groundwater remediation should not be delayed until possible additional sources of contamination are fully investigated. The information gathered to date indicates that releases from the UMC facility are, at the very least, one of the primary sources of the groundwater contamination affecting the site. Should additional information indicate the contribution of CCl_4 contaminants from other sources, EPA will, if necessary, reevaluate the selected alternative to determine whether modifications to the remedy are appropriate. However, even assuming, arguendo, that releases from other sources have also contributed to the groundwater contamination affecting the site, UMC is jointly and severally liable with such other PRPs (if they exist) for the groundwater contamination at the site.

10. UMC claims that all CCl_4 has been removed from vadose zone soils, as documented in the UMC Vacuum Assessment Report, dated March 23, 1987, and unless there is reason to reject this report, the EPA FS should be revised to reflect the success of the vacuum extraction system. UMC further states that it should not be stated that CCl_4 remains in the soil and acts as a persistent secondary source of contamination to the groundwater.

    EPA RESPONSE: The vacuum extraction system would only have been able to remove the vapor fraction of the CCl_4 and that portion of the liquid that was readily converted to vapor. Most of the of CCl_4 that was sorbed to soil particles would not have been removed. Results of the soil sampling conducted by UMC at four locations where CCl_4 concentrations were once highest, as presented in the UMC Vacuum Assessment Report of 1987, are not conclusive evidence that no more CCl_4 remains in the unsaturated zone. Also, the consistently high levels of CCl_4 detected in the on-site well UE-1 give weight to the argument that a source of CCl_4 does exist in the unsaturated zone.

11. UMC believes EPA's preferred alternative is technically infeasible, due to the presence of conduit flow which makes remediation difficult, and is not justified. Compliance with the MCL of 5 ppb in karst terrain is technically impracticable from an engineering perspective, UMC believes. UMC also asserts that the locations for the proposed extraction wells are remote, which will cause difficulty in gaining access for their installation and maintenance.

    EPA RESPONSE: Karst terraines have differing characteristics world wide. This portion of the karst of Puerto Rico is known to be dominated very strongly by diffuse flow. A study of the hydrogeology in the Barceloneta area of Puerto Rico (both literature and field studies) has shown that springs fed by diffuse flow predominate in the Cano Tiburones (Quinlan, 1986, Beck, 1987, Field, 1988). An examination of the springs in the Cano Tiburones, the water level measurements in wells in the area, and the ability of existing water wells to show measurable levels of CCl_4, lead to the conclusion that diffuse flow is the dominant flow component in the immediate area. Because of this, contaminant recovery using groundwater extraction wells is feasible, given properly located wells. Although conduit flow may exist, the selected alternative will be designed to primarily address the diffuse component of the flow, although the conduit component of the flow may also be intercepted by the well system. To some extent, the success of the UE-1 groundwater extraction well at removing contaminants from the aquifer lends support to the technical feasibility of extraction wells for contaminant recovery at this site.

Although the overall goal of the clean up action is to meet the MCL of 5 ppb for CCl_4 throughout the aquifer, EPA is not asserting at this point that the selected alternative will achieve this. It may be technically infeasible or impracticable to do, given the unknowns of the hydrogeology. However, the selected alternative is capable of removing contaminant mass from the aquifer, thereby reducing contaminant levels, and in doing so, will provide for the following protective measures to human health and the environment:

- reduction of cancer risk levels which will decrease the reliance on institutional controls over future potable well installations in the aquifer,
- protection of presently unimpacted portions of the aquifer (CCl_4 levels less than the MCL of 5 ppb),
- prevention of further contamination of presently impacted portions of the aquifer,
- possible attainment of the MCL of 5 ppb for CCl_4 in large portions of the existing impacted areas, and
- reduction of risk to Cano Tiburones and the life it supports.

EPA agrees with UMC's claim that the locations of the proposed extraction wells under the selected alternative are remote, which may cause difficulty in gaining access for their installation and maintenance. EPA, however does not consider this difficulty sufficient justification to reject the selected alternative.

12. UMC claims that the cost/benefit analysis for the preferred alternative was inadequately performed by EPA. In addition, UMC asserts that the preferred alternative is not cost-effective because there is no documented risk to human health and the environment from the 1982 UMC incident.

EPA RESPONSE: When selecting a remedy, EPA performs a cost-effectiveness analysis, and in doing so, judges an alternative first on its degree of effectiveness. Of the alternatives which provide for the required degree of effectiveness, the least costly is selected.

EPA believes that the selected alternative is cost-effective. Extraction wells will be added sequentially, up to a total of approximately four additional wells aside from the initial two new wells, provided the wells are shown to be effective or have a high probability of success at removing contaminants from the aquifer.

An endangerment assessment report, dated September 12, 1988, was prepared for the UMC site. This report documents the existence of potential risks to human health and the environment from the 1982 UMC incident if no further remedial action were to be taken.

Risks to human health exist if institutional controls restricting aquifer use fail, and new wells are installed for drinking purposes. In addition, risks to the environment exist due to the fact that the groundwater is contaminated. As a result of this contamination, the aquifer, as a resource, is lost without remediation.

13. UMC believes EPA erred by using the MCL for CCl_4 as an applicable or relevant and appropriate requirement (ARAR) based upon its classification of the aquifer as Class I groundwater.

    EPA RESPONSE: EPA has reconsidered its prior classification of the aquifer as Class I groundwater and has reclassified the aquifer a Class II groundwater (current or potential source of drinking water). Although the water table aquifer is replaceable (i.e., wells can be pumped from the confined aquifer for potable water), it still remains a potential drinking water source. Therefore, MCL's are still appropriate remediation levels.

4. UMC believes that the rationale for EPA's selection of the preferred alternative is simply that the technology is available.

    EPA RESPONSE: This statement is not true. There are unacceptable existing and/or threatened environmental and public-health impacts that make EPA's selected alternative necessary and appropriate.

15. UMC believes that due to the heterogeneous nature of the aquifer, the success of one extraction well does not ensure that the location selected for the next well will be as effective.

    EPA RESPONSE: EPA agrees with UMC's statement to a certain extent. However, EPA believes that with a very carefully conducted office and field investigation, including a lineament and fracture trace analysis, extraction wells could be placed with a relatively high degree of confidence that these wells would be successful at removing contaminants from the aquifer. The well system called for under the selected alternative, as an interim remedy, will be evaluated within 5 operational years to determine the practicability and cost-effectiveness of cleaning up all or portions of the aquifer and to specify the type of further action to be taken.

16. UMC claims that the EPA FS acknowledges that because of potential salt water intrusion problems, USGS and PRDNR would take the positio that EPA's preferred alternative would not meet the substantive requirements of a permit. UMC also says that USGS has questioned the effectiveness of chloride monitoring and groundwater recharge in preventing salt water encroachment.

    EPA RESPONSE: It is incorrect that the EPA FS "acknowledged" the likelihood that USGS and PRDNR would probably not grant a permit. Both USGS and PRDNR reviewed and submitted comments on EPA's FS and PRAP. Their comments have been incorporated into this Responsiveness Summary. Neither USGS nor PRDNR commented that the selected alternative would not meet the substantive requirements of a permit, nor did USGS question the effectiveness of the chloride monitoring and groundwater recharge systems called for under the selected alternative in preventing salt water encroachment. The chloride monitoring and groundwater recharge systems presented in the FS and ROD will be extensively refined during design with the full participation of USGS and PRDNR.

17. UMC criticizes EPA's preferred alternative by stating that EPA cannot quantify the degree to which the remedy will speed up the restoration of the aquifer.

    EPA RESPONSE: EPA believes that the selected remedy, which is capable of removing contaminant mass and reducing contaminant concentration levels within the aquifer, will restore the aquifer more quickly than attenuation which relies totally or predominantly on natural movement and dispersion of the contaminants. EPA does not believe that quantification of the time frame for restoration is needed to justify our position that the selected remedy is more protective of public health and the environment than the alternatives which rely on natural processes or limited extraction of groundwater.

18. UMC claims that one measure of cost-effectiveness is the cost to remove each gallon of CCl_4, and that the preferred alternative proposed to spend as much as 14.5 million dollars to remove the estimated 50 gallons of CCl_4 remaining in the aquifer.

    EPA RESPONSE: EPA does not believe that UMC's measure of cost-effectiveness, referred to above, is a sound approach to evaluating costeffectiveness. In addition, UMC's argument assumes that there are only 50 gallons of CCl_4 left in the groundwater. UMC has not presented a sound basis to support this claim.

19. UMC claims EPA's FS does not fully identify explanations for the mass balance discrepancy, that is, the fact that the amount of CCl_4 removed from the soil and groundwater is greater than the amount of CCl_4 released from the ruptured tank. UMC states that there are additional explanations as follows: 1) inaccuracy of the measurement of vented CCl_4 vapors removed, and 2) inaccuracy in the estimate of the amount of CCl_4 lost. UMC believes these events are much likelier reasons for mass balance discrepancies than the possibility of a previous spill, as stated in the EPA FS. UMC says that all tanks previously located in the tank farm area were inspected following the spill and that results indicate that none could have contributed to significant quantities of CCl_4 in the soil and groundwater.

In addition, UMC refers to sampling and analysis of the AH Robins well in May 1981, which did not reveal any CCl_4 in the groundwater. UMC implies that a previous leak from the UMC tank farm would probably have been detected in the Ah Robins well during the 1981 sampling.

EPA RESPONSE: EPA believes that UMC's additional explanations for the mass balance discrepancy are possible. However, these explanations are no more probable than the explanations presented in the EPA FS. EPA was unaware that inspections were performed on every tank in the tank farm. The 1984 Geotec RI/FS Report only included inspection reports for thirteen tanks in the tank farm. Inspection reports for tanks FA-102, 103, 105 and 128, which were used to store CCl_4 at one time or another, were not included. The Geotec report indicated the possibility of additional spills or leaks near the tank farm from loading and unloading stations and from maintenance work on pipe and tank fixtures within the tank farm. A possibility also exists that the ruptured tank could have been slowly leaking for a period of time before its failure was discovered.

With regards to the sampling of the AH Robins well, it is possible that additional tank leaks and/or spills could have occurred between May 1981 and August 1982, or that leaks/spills that occurred before May 1981 had not yet impacted the AH Robins well.

20. UMC claims EPA's FS does not contain alternative methods of remediation as required by the National Contingency Plan (NCP). UMC also states that EPA's "No Action" alternative is not truly a "No Action" alternative.

    EPA RESPONSE: Although not present in the EPA FS report, EPA considered alternative treatment technologies for addressing the residual groundwater contamination. These technologies are presented in the Record of Decision.

    EPA believes that its No Action alternative is a *bona fide* No Action alternative. The fact that it would involve changing the "status quo" by ceasing the pumping of well UE-1 does not mean that the alternative is not a No Action alternative.

21. UMC claims that, since only approximately 50 gallons of material from the spill remain in the aquifer, at most, EPA's preferred alternative will only speed up the restoration of the aquifer by an insignificant degree.

    EPA RESPONSE: UMC presents no technical argument for its belief that only 50 gallons of material from the spill remain in the aquifer. In addition, EPA believes that the selected alternative is capable of significantly speeding up restoration of the aquifer. The selected alternative, as an interim remedy, will be reevaluated within five years of operation of the well system to determine the system's capability of restoring all, or portions of, the aquifer.

22. A community member wanted to inform EPA that rainwater runoff discharges into two sinkholes in the area; one at Cruce-Davila, and the other at the UMC facility, and was concerned whether the preferred alternative included discharge into one of these sinkholes.

    EPA RESPONSE: The selected alternative includes discharge of treated groundwater into the sinkhole located at the UMC facility. EPA does not consider the rainwater runoff discharging into this sinkhole to be of any concern.

23. A community member inquired as to the location of the sampling point where CCl_4 was recently detected at the Cano Tiburones.

    EPA RESPONSE: La Cambija spring, which feeds into Cano Tiburones, is where recent sampling conducted detected 13 ppb of CCl_4. This spring is located approximately 2000 feet south of Cano Tiburones.

24. A community member told EPA that in order to comment adequately on the preferred alternative, exact locations of the extraction wells, discharge points and monitoring wells would be required.

    EPA RESPONSE: The exact locations of these items will be determined during the design phase of the project. The FS report illustrates only conceptual locations of where these items would be placed, as can be seen on Figure 15 in the FS report. EPA does not believe that actual locations are crucial to being able to comment on the selected alternative.

Extent of Contamination

25. EPA was asked what is being done currently to control contaminated water and how far the area of contamination extends.

    EPA RESPONSE: Since 1984, UMC has been operating the UE-1 groundwater extraction well, which extracts contaminated groundwater, treats this water with an air stripper, and discharges treated water into an existing sinkhole. The UE-1 well is only capable of controlling a small portion of the contamination, that portion nearest to the UMC property. This well has no control over the contamination which currently exists outside of the well's cone of depression. Based on 1988 sampling data, it appears that the contamination within the diffuse component of the groundwater flow extends approximately 8500 to 9000 feet north of the UMC property and may encompass approximately one square mile. This delineation is based solely on the location of the wells which limits the accuracy of delineating the extent of contamination. EPA believes the CCl_4 contamination which exists within the conduit flow portion of the aquifer may extend beyond what is reported above.

26. A community member asked if the contamination was moving south from the site.

    EPA RESPONSE: Historic as well as recent sampling of the groundwater indicates that the contamination is migrating to the north, as is expected, following the direction of regional groundwater flow.

27. A community member asked if the contaminated groundwater could rise up and contaminate the soil.

    EPA RESPONSE: It is possible that contaminated groundwater could rise high enough to pollute the overlying soils. This possibility depends on the depth of the soil profile and the rise of the groundwater. EPA believes that this is an unlikely possibility, and if it has occurred, would not affect dissolved groundwater concentrations significantly.

28. A community member asked EPA to explain why the Garrochales #3 well was not contaminated if the UMC site and the Cano Tiburones were both contaminated and the Garrochales #3 well lies between them.

    EPA RESPONSE: Recent as well as historic sampling of the Garrochales #3 well indicates CCl_4 contamination at levels below the MCL of 5 ppb. It is possible that given the varied groundwater flow paths typical of karst formations, some of the contaminated groundwater could have bypassed the Garrochales #3 well and migrated to the Cano Tiburones.

29. The President of the Municipal Assembly of Barceloneta asked if any sampling at Cano Tiburones in Arecibo was conducted to see if contaminants from the 1982 UMC incident are migrating towards Arecibo.

    EPA RESPONSE: EPA was unaware of any sampling conducted at the Cano Tiburones in Arecibo. EPA believes it is unlikely that the migration of contaminants present in the groundwater, resulting from the 1982 UMC incident, would pose a risk to the Cano Tiburones in Arecibo. UMC informed the community at the public meeting that it had conducted sampling in 1985 of the Cano in Arecibo and did not detect the presence of CCl_4 contaminants.

30. EPA was asked what the source of water was to the communities of Boca, Punta Palmas and Palmas Altos.

    EPA RESPONSE: EPA did not know the answer to this question. The Mayor of Barceloneta informed the community at the public meeting that the communities in question lie outside of the area which was studied by EPA in the FS report.

Effects on Human Health and the Environment

31. Several community members asked what effect CCl_4 contaminants would have on the Cano Tiburones and the aquatic life it supports.

    EPA RESPONSE: Little sampling has been conducted in the past in the Cano Tiburones to allow for an accurate determination of CCl_4 contaminant levels present. Sampling of one spring, La Cambija, which feeds into Cano Tiburones, was conducted by EPA in January 1988. Results indicate CCl_4 levels at 13 ppb. The FS report states that dilution of contaminants is expected to occur as the contaminants migrate from their present locations and discharge into Cano Tiburones. The amount of dilution cannot be accurately determined. However, it is expected that concentrations entering the Cano would be low. The endangerment assessment report prepared for the UMC site estimated through modelling that a maximum CCl_4 concentration level of 262 ppb would be detected in the Cano approximately 11.4 years after the spill occurred if no further remedial action was to be taken. Chronic human ingestion of the water in Cano Tiburones was estimated to result in a 5.8×10^{-5} cancer risk. Ingestion of contaminated fish is not expected to pose a threat to human health due to the low bioconcentration factor of CCl_4 which results in minimal uptake by fish. Chronic toxic effects of contaminants may adversely effect aquatic life of the Cano. However, impacts to aquatic life from existing and future contaminant concentrations are expected to be low.

32. What risk did local residents face in the past and what is the current risk to residents from the contamination until the remedy is implemented?

    EPA RESPONSE: Shortly following discovery of the spill in September 1982, local water supply wells were sampled. Those found to be contaminated or threatened were shut down. UMC provided alternate water supplies. Therefore, any risk to local residents in the past from drinking contaminated water would be low. At the present time, the levels of CCl_4 in the Garrochales #3 well do not exceed the MCL of 5 ppb. Human health is currently not at risk. However, the endangerment assessment report documented potential risk to human health if no further remedial action were taken at the site to reduce contaminant concentration levels in the aquifer.

    Installation of an air stripper at the Garrochales #3 well would be the first of the remedial actions called for under the selected alternative to be implemented at the site. Design and installation of the system would be placed on a priority basis to reduce any potential exposure to contaminated water from this well.